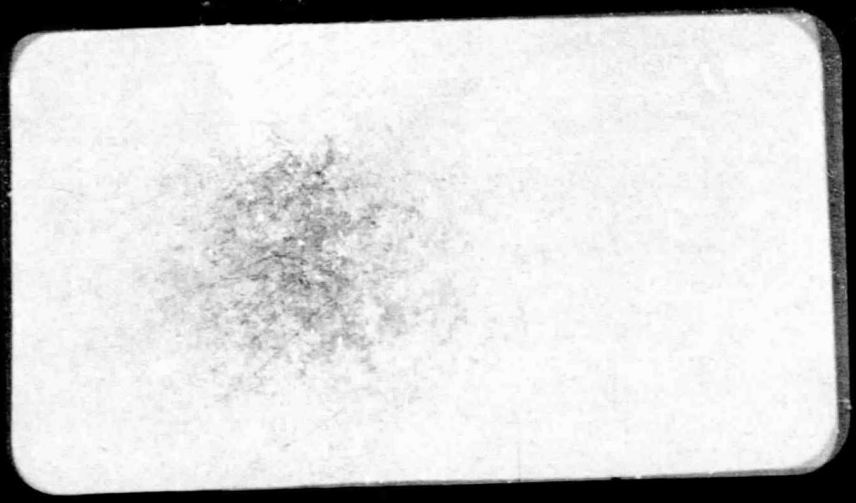

GRUMMAN

SPACE FABRICATION DEMONSTRATION SYSTEM

QUARTERLY PROGRESS REPORT NO.2

May 17, 1977 - August 26, 1977

NASA/MSFC Contract NAS 8-32472

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, NEW YORK 11714

NSS-SFDS-LR013
Contract NAS8-32472
August 30, 1977

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Attention: Erich E. Engler, COR
EP 13 Bldg. 4610

Subject: SPACE FABRICATION DEMONSTRATION SYSTEM - Quarterly Progress Report No. 2 - Reporting Period: May 17, 1977 - August 26, 1977

Enclosure: (1) SFDS Quarterly Review Vu-graph Presentation Copy - 26 August 1977

Reference: (a) SFDS - Monthly Progress Letter No. 3, June 30, 1977
(b) SFDS - Monthly Progress Letter No. 4, July 30, 1977

SUMMARY

The Space Fabrication Demonstration System (SFDS) program concluded its second contract quarter year with a quarterly review meeting held at NASA-MSFC on 26 August 1977. This quarterly progress report as agreed upon by NASA-MSFC is comprised of the data presented at this meeting, enclosure (1), supplemented by our previous monthly progress letters, references (a) and (b).

During discussions held with NASA-MSFC in preparation for this quarterly review it was agreed to substitute incremental critical design reviews for the one CDR which was to be held at this time in order to permit continued sequential subsystem design concurrance to occur without impacting the SFDS subsystem assembly and test schedule. These are indicated on Figure 1.

Action items resulting from these meetings still be to satisfied are:

- Grumman will study the required SFDS assembly alignment tolerances and include these on the final assembly drawing.
- NASA-MSFC will furnish Grumman with test data on a pin-ended beam test similar to that performed by Grumman for a fixed-ended beam in association with this program.

DISCUSSION

WBS 1.1 PROGRAM MANAGEMENT

Continued detailed review of tasks committed versus tasks completed to date have kept the SFDS program essentially on schedule. Figure 1 - SFDS Master Program Schedule, shows our progress as marked to reflect percent task completion, as applicable. Deviations from and changes made to the schedule are noted below.

WBS 1.2 DESIGN and DEVELOPMENT

1.2.1 Structural Member Development

Process definition includes final selection of recommended thermal coating for the structural truss. Various alternate finishes are still being examined.

Detail truss design and analysis is complete except for completion of the final memo report with conclusions and recommendations for future action.

The material for manufacture of the truss for the truss/joint tolerance tests has been received. The schedule has been updated to reflect the expected test plan and test completion dates.

Data associated with verification of the design of the basic "building block" truss for this reporting period are included in enclosure (1).

1.2.2 Fabrication Facility Design

The schedule has been revised to reflect the completion of detail, dimensioned design layouts of each subsystem. This was done to comply with the agreement reached with NASA-MSFC that Grumman would furnish these for each incremental critical design review in lieu of the design layout drawings we had originally anticipated furnishing.

The configuration layout will be completed upon finalization of each subsystem design layout.

The schedule for the roll forming subsystem has been extended to include completion of the detail design of the rolling mill drive, cap stock feed encouder mounting and cap stock supply reel design. NASA-MSFC has requested that consideration be given to have one of the supply reels include not only simple reload capability but also a self-threading feature to demonstrate how this might be accomplished on a space flight article being used to fabricate large space structure building block trusses.

The schedule for the magazine and dispensing subsystem has been extended to include design consideration of simple cross-brace reloading capabilities for one magazine/dispensing subsystem to demonstrate long range space structure fabrication application has been implemented at the request of NASA-MSFC. Though concurrance with this design is not expected until December, critical long lead items have been released for request for quote in order to expedite purchase, receipt of components, detail parts manufacture and subassembly.

The weld process subsystem detail design completion date has been extended to accomodate the inclusion of six transformers and their related cabling as requested by NASA-MSFC rather than the one transformer originally contemplated. This was done in order to provide a closer match to the SST/payload power supply capabilities. Also included in this schedule extension is the completion of the diagonal brace weld/clamp mechanism.

A mock-up of the truss cut-off has been built and tested. Detail design has been initiated. With completion in October and release to the shop at that time it is expected that detail parts fabrication will be completed on time.

Development testing remains an open item. It will remain so until all subsystem detail designs have been completed and the need for construction of subsystem mock-ups or concept verification tests have been satisfied. Determination of series spotweld electrode life continues.

It is anticipated that the above schedule changes will not impact the overall delivery schedule of the SFDS.

WBS 1.3 FABRICATION and ASSEMBLY

1.3.1 Detailed Parts

Fabrication of detail parts for the roll forming mill continues at the Yoder company. Assembly and test of these subsystem components is anticipated next month.

The magazine and dispensing subsystem components are being held-up pending completion of the detail design layout completion.

1.3.2 Assembly

Composite development forming tests have been completed within the scope of effort defined for this program. Conclusions and recommendations for futher in-house development efforts have been generated and are being submitted for corporate management approval.

WBS 1.4 TEST

No tests associated with the final products, the structural member or fabrication facility, were performed during this reporting period.

WBS 1.5 FLIGHT DEMONSTRATION PLANNING

The preliminary Flight Demonstration Program Plan, Cost and Schedule were completed and submitted to NASA-MSFC during this reporting period. We are waiting for comments and/or questions from NASA-MSFC before proceeding with updating materials contained within the report in preparation for the final plan.

CONCLUSION

Satisfactory progress has been accomplished during this reporting period.

Face to face discussion with NASA-MSFC helped to understand their concept of the type and nature of documentation they desired before concurring on developmental subsystem detail design.

RECOMMENDATIONS

Continued close management surveillance by NASA-MSFC and Grumman program management personnel.

Implementation of monthly or bi-monthly meetings for face to face discussions to keep all parties knowledgeable of what is being provided and what is expected so that no further uncertainties may develop.

Should you have any questions or comments with regard to the above or the enclosed, please contact us.

Very truly yours,

GRUMMAN AEROSPACE CORPORATION

Walter K. Muench

Walter K. Muench
SFDS Program Manager

WKM:dm
cc: Distribution NASA-MSFC
Distribution Grumman

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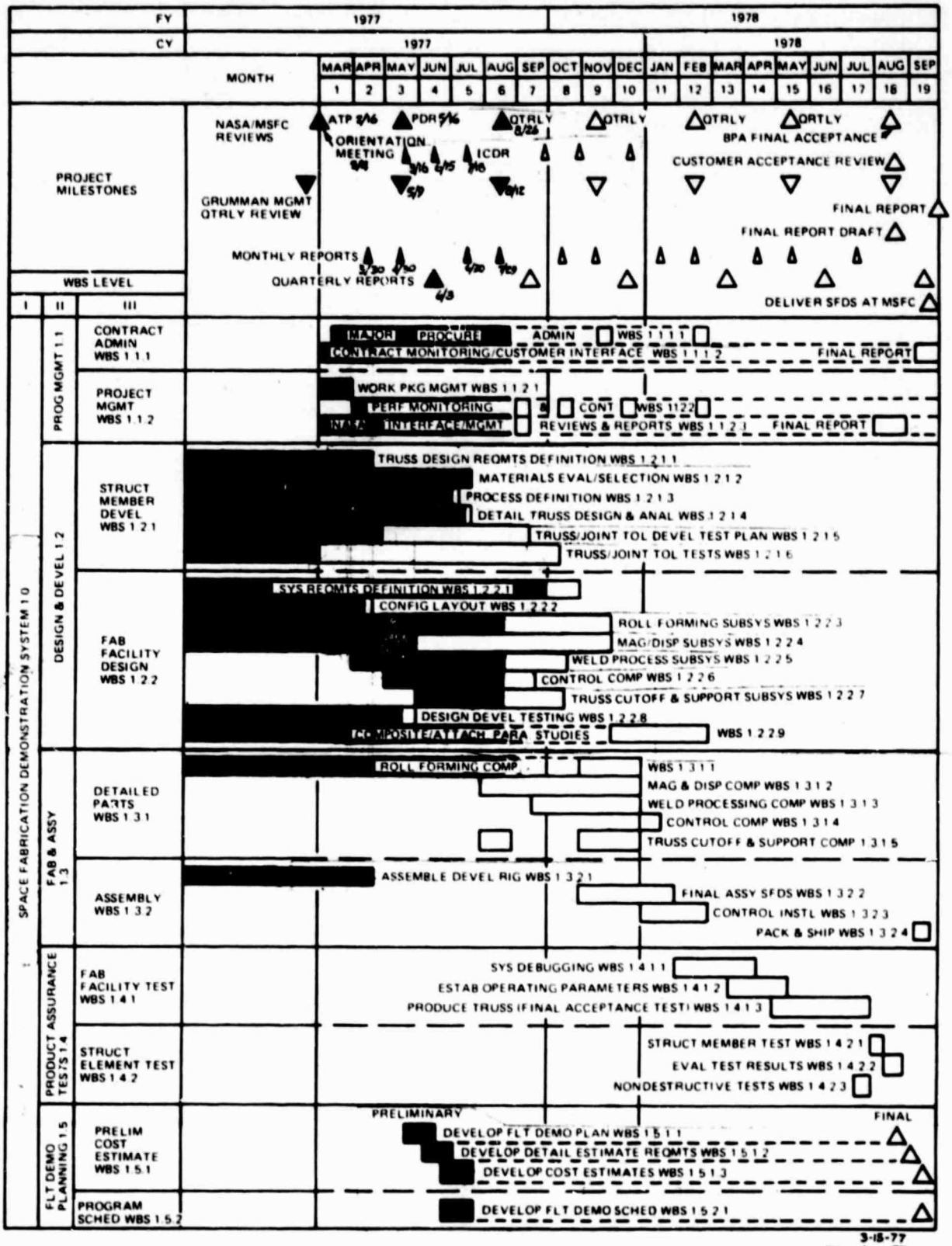
SFDS MASTER PROGRAM SCHEDULE



3-18-77
REV 4-15-77
" 5-13-77
" 5-17-77
" 6-16-77
" 7-16-77
" 8-30-77

GRUMMAN

FIGURE 1

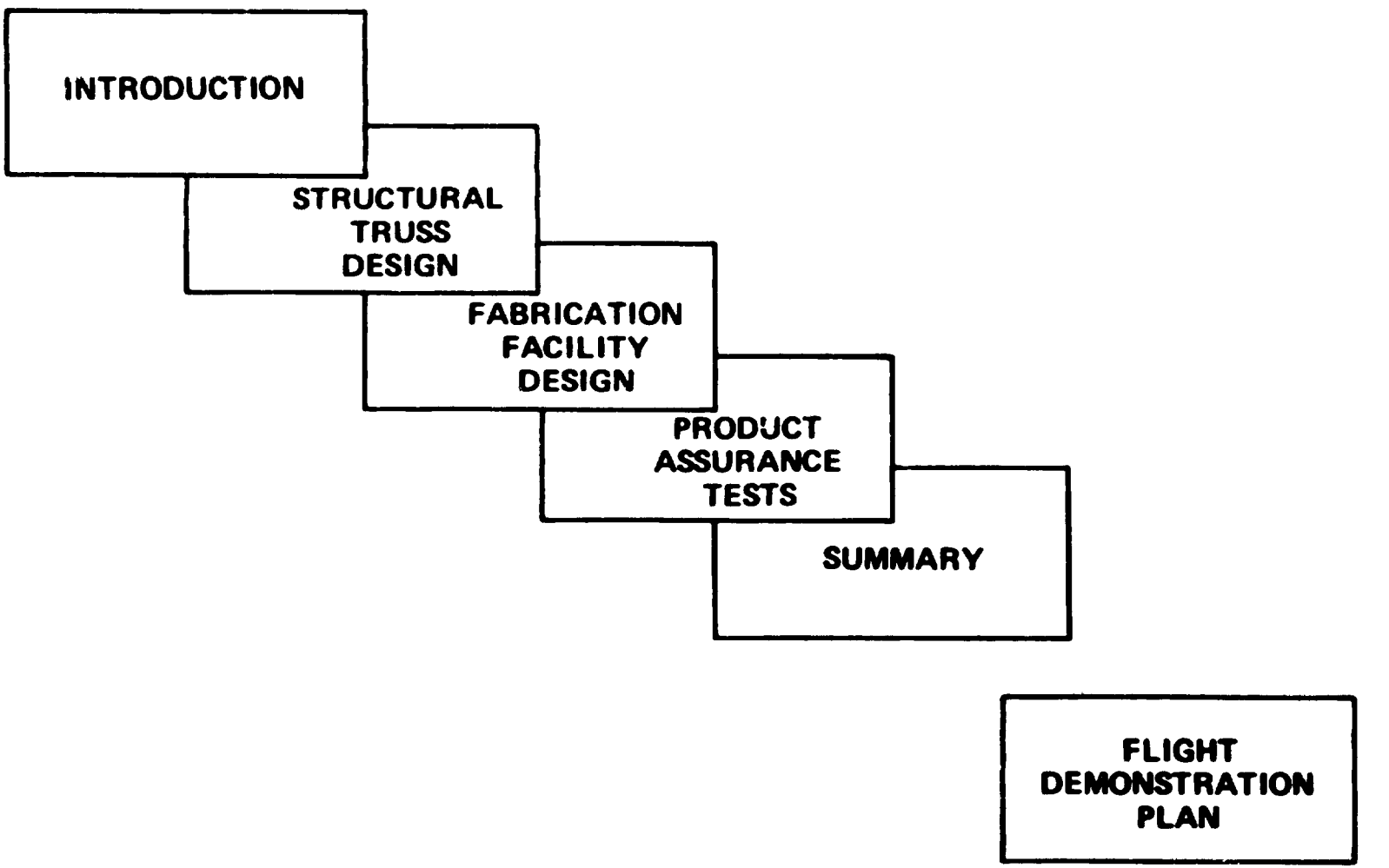
SPACE FABRICATION DEMONSTRATION SYSTEM

QUARTERLY REVIEW

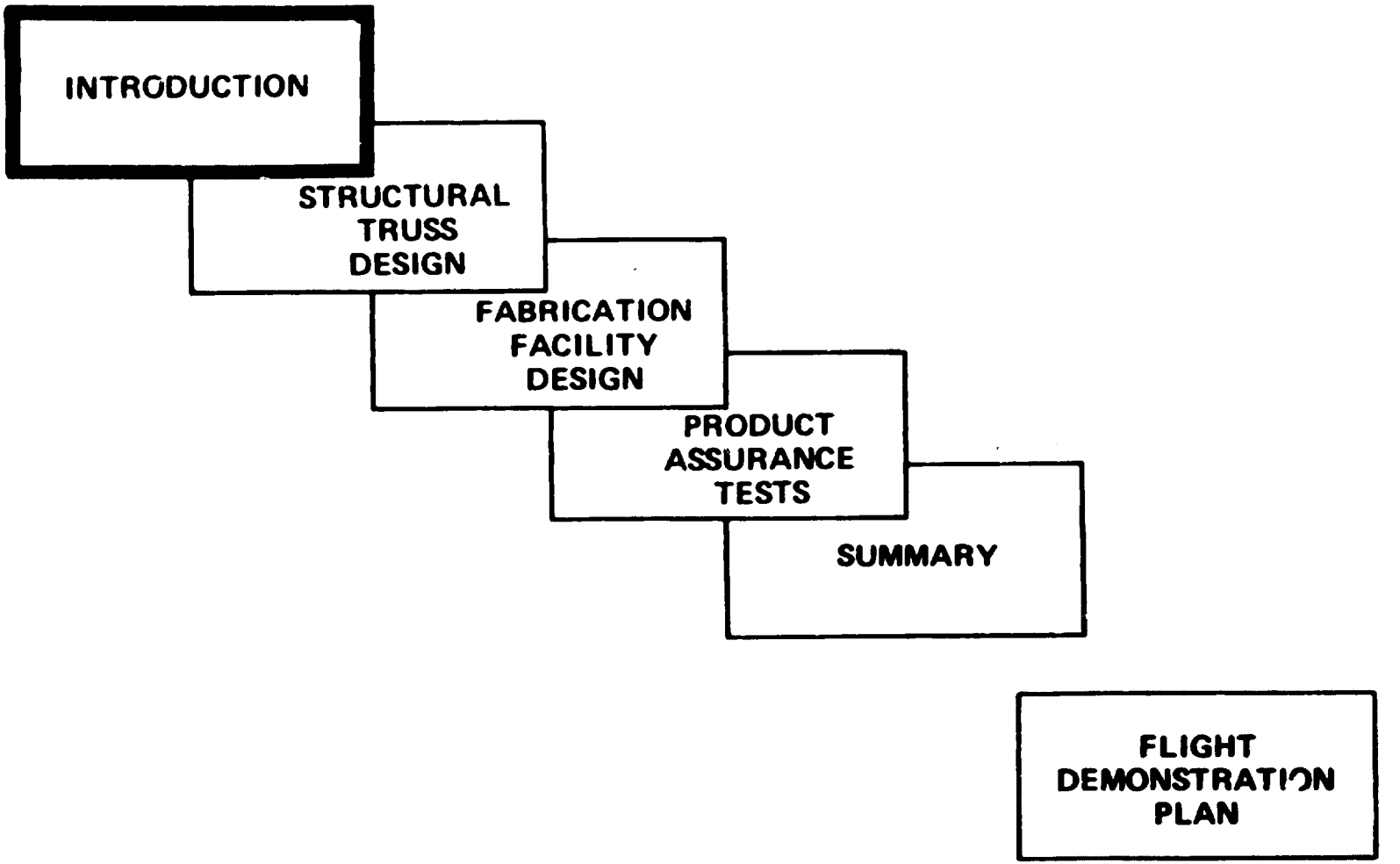
PRESENTED TO

GEORGE C. MARSHALL SPACE FLIGHT CENTER

26 AUGUST 1977


INTRODUCTION
STRUCTURAL TRUSS DESIGN
FABRICATION FACILITY DESIGN
PRODUCT ASSURANCE TESTS
SUMMARY
FLIGHT DEMONSTRATION PLAN

2105-002W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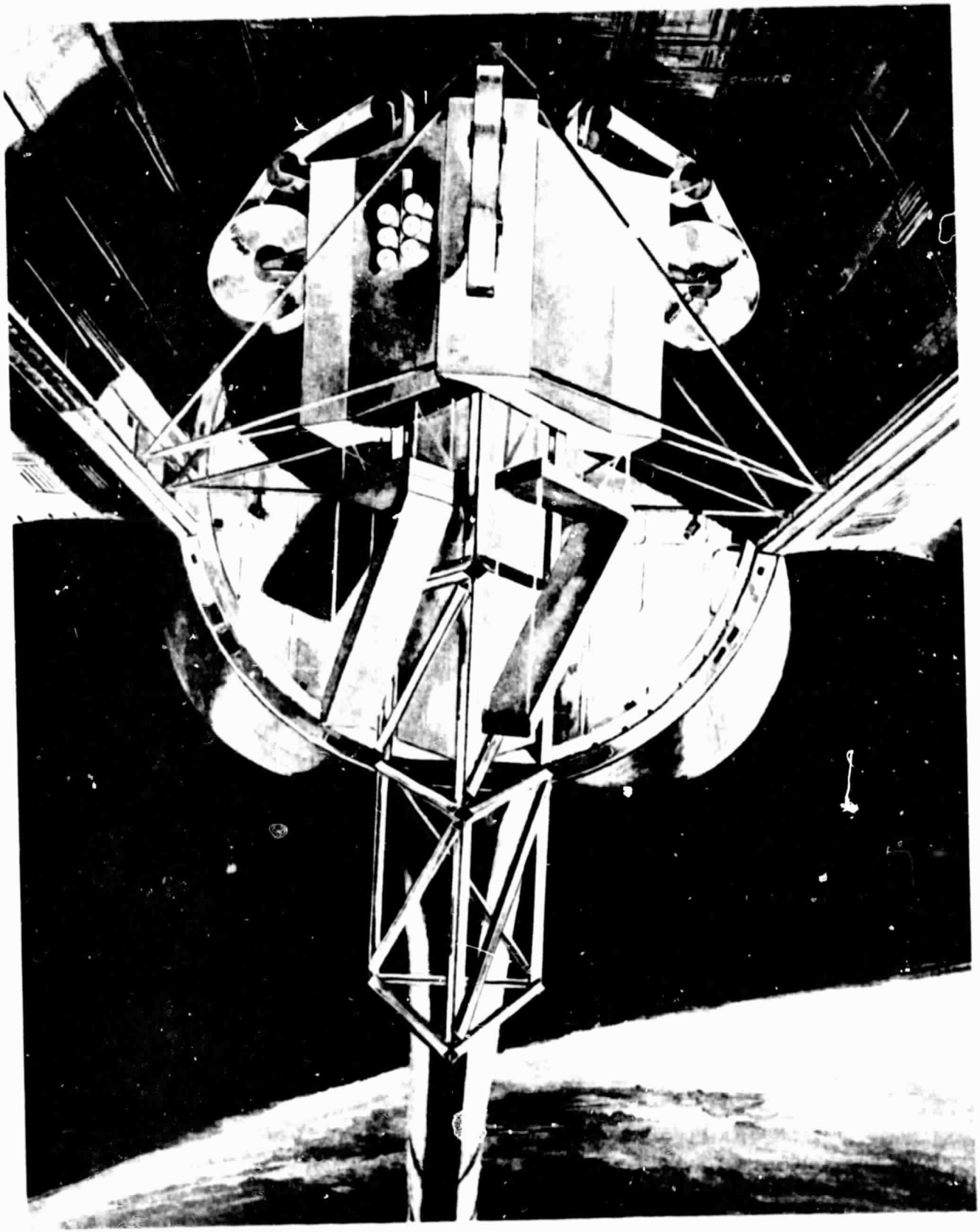
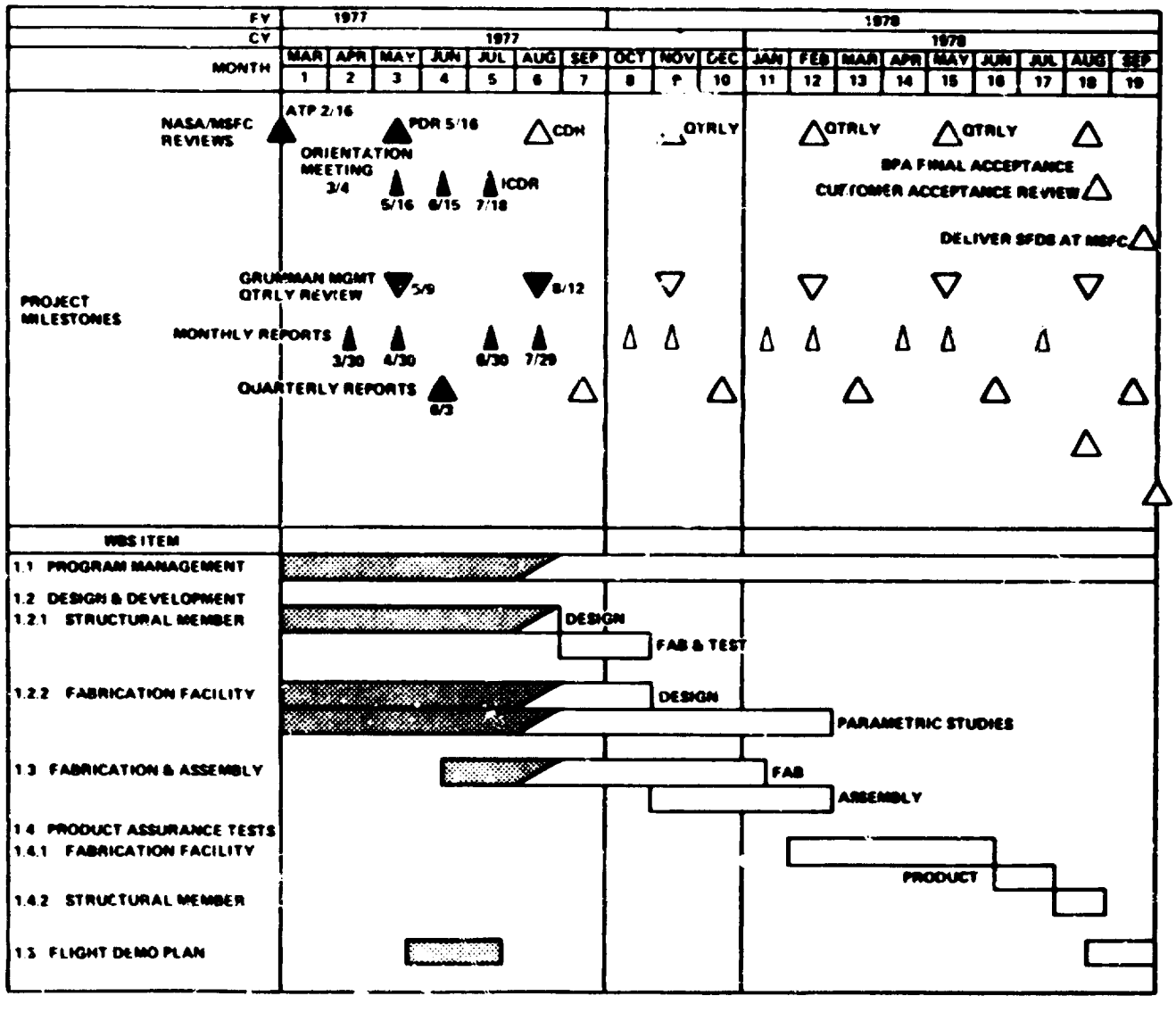


SFDS MASTER PROGRAM SCHEDULE

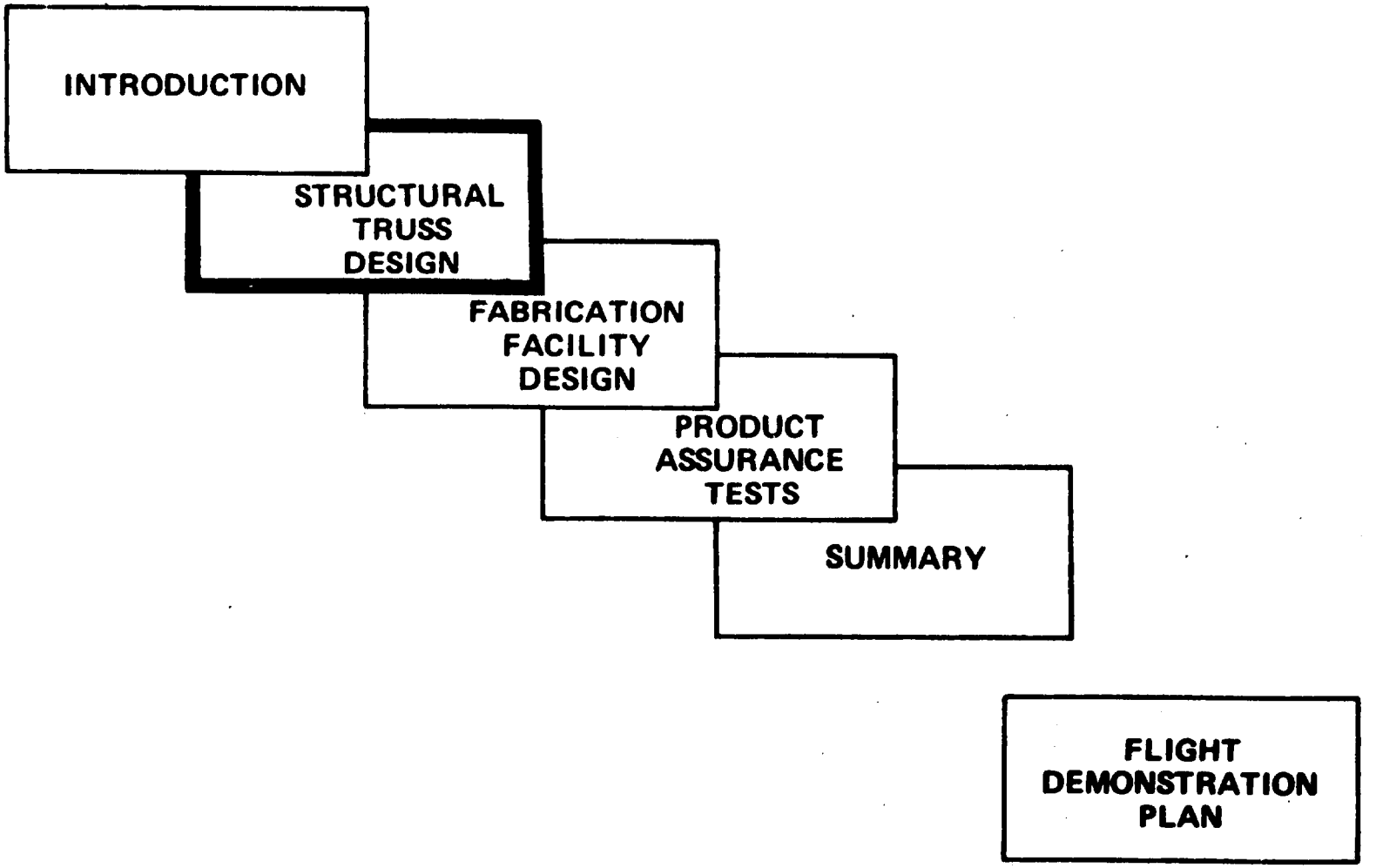


2105-010W

SFDS MATERIALS REQUIREMENTS

COMPONENTS	RFQ	PO		DELIVERY			REMARKS/REFERENCE
		REL'D	ACT'L	ROD	EOD	ACT'L	
TEST ELECTRODES			3/1	4/11	5/4	5/4	
ALUMINUM STOCK			4/14	7/1	8/19		
CONNECTORS	5/18	6/1	7/20*	10/19	8/16		
CONTROL PROCESSOR	5/18	6/13	7/20*	10/31	10/31		
ROLLING MILLS	5/23	6/20	6/30	9/15	11/18		
DRIVE CONTROLLERS	5/23	6/20	7/20	9/26	9/26		
WELD EQUIPMENT	5/23	6/20	–	10/17			AWAITING QUOTE FROM VENDOR
WELD ELECTRODES	5/30	6/27	–	9/5			RELEASE OF P.O. PENDING LIFE TESTS
POWER CABLES	6/6	7/1	–	10/14			SAME AS ABOVE
ACTUATORS & MOTORS	6/6	7/1	7/26	9/12	8/16		
REEL & GUIDE	7/20	7/27	–	9/15			MAKE ITEM
CUT-OFF MECHANISM	7/5	8/1	–	–	–	–	MAKE ITEM
SUPPORT STRUCTURE	8/1	8/8	–	9/1			MIN-MAX STOCK
CONTROL SENSORS	7/11	8/15	7/26	8/1	7/25	7/25	
WIRING	7/11	8/15	–	10/17	10/17		
TRUSS SUPPORT	9/12	9/19	–	10/17			MIN-MAX STOCK
POWER SUPPLY			6/20	8/1	7/7	7/1	

GRUMMAN


INTRODUCTION
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STRUCTURAL DESIGN CONDITIONS ONE METER DEEP BEAM

DESIGN CONDITION I – FABRICATION IN ORBITER PAYLOAD BAY

- ORBIT 215 NM 28.5° INCLINATION
- CRITICAL LOAD COND: ORBITER RCS THRUSTER FIRING
- THERMAL CONDITION: ORBITER +Y AXIS EARTH POINTING

DESIGN CONDITION II – SATELLITE SOLAR POWER SYSTEM (SSPS)

- ORBIT: GEOSYNCHRONOUS, SUN ORIENTED
- CRITICAL LOAD COND: STATION KEEPING MANEUVER
- THERMAL COND: SOLAR ARRAY – SUN POINTING
  MW ANTENNA – EARTH POINTING

DESIGN CONDITION I

- LOADS DATA
- TEMPERATURE DATA

DESIGN CONDITION I – BEAM FABRICATION IN ORBITER PAYLOAD BAY

	ROTATIONAL ACCEL. DEG/SEC^2			
RCS SYSTEM	$\pm\ddot{\theta}$	$+\ddot{\theta}$	$-\ddot{\theta}$	$\pm\ddot{\psi}$
PRIMARY THRUSTER	1.2	1.4	1.5	0.8
VERNIER THRUSTER	0.04	0.03	0.03	0.02

ROLL ϕ

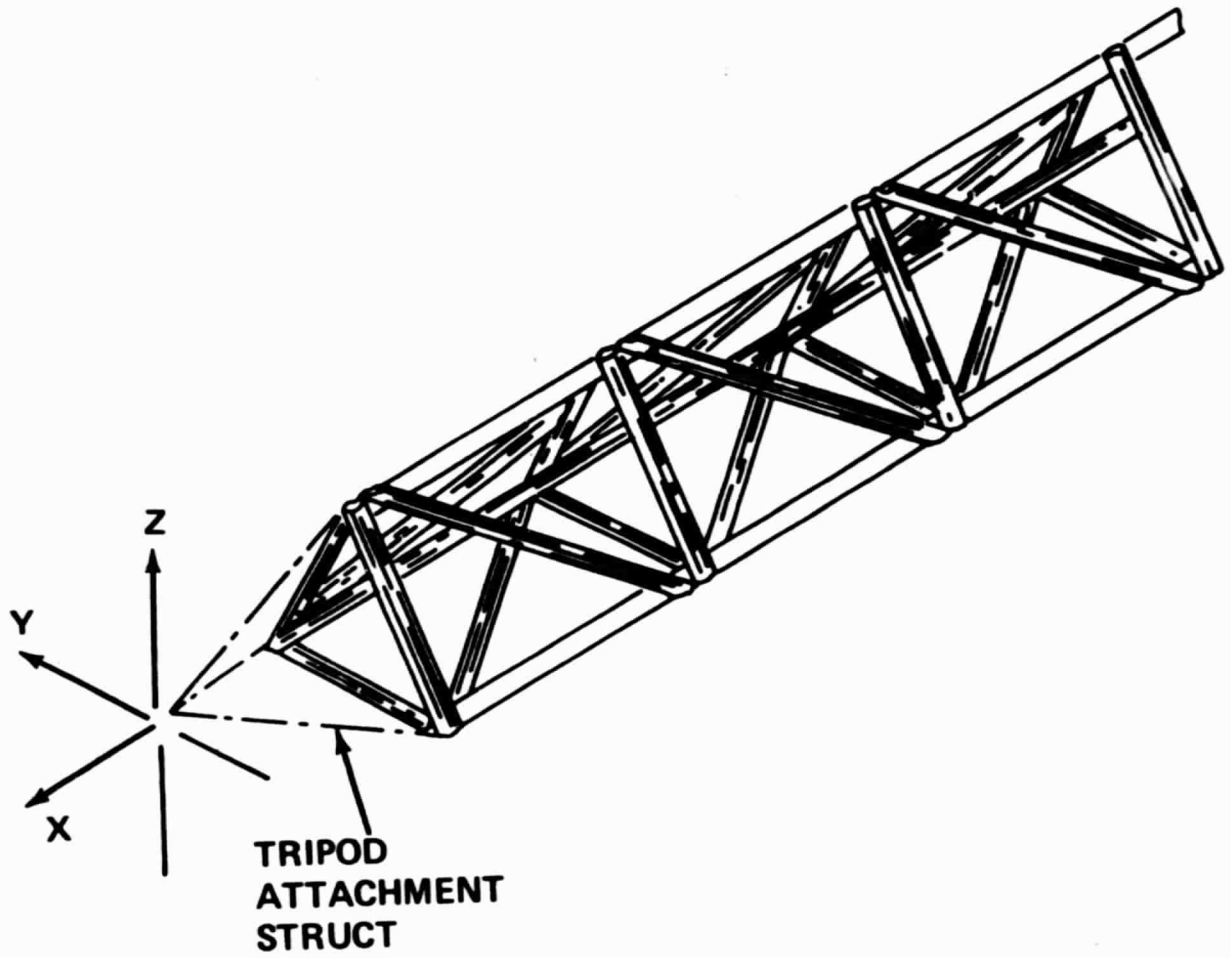
PITCH θ

YAW ψ

ULTIMATE FACTOR OF SAFETY 1.40

$\ddot{\theta}$ = 1.5 SEC/SEC^2 USED TO DESIGN BEAM

"BUILDING BLOCK" TRUSS – ONE METER DEPTH



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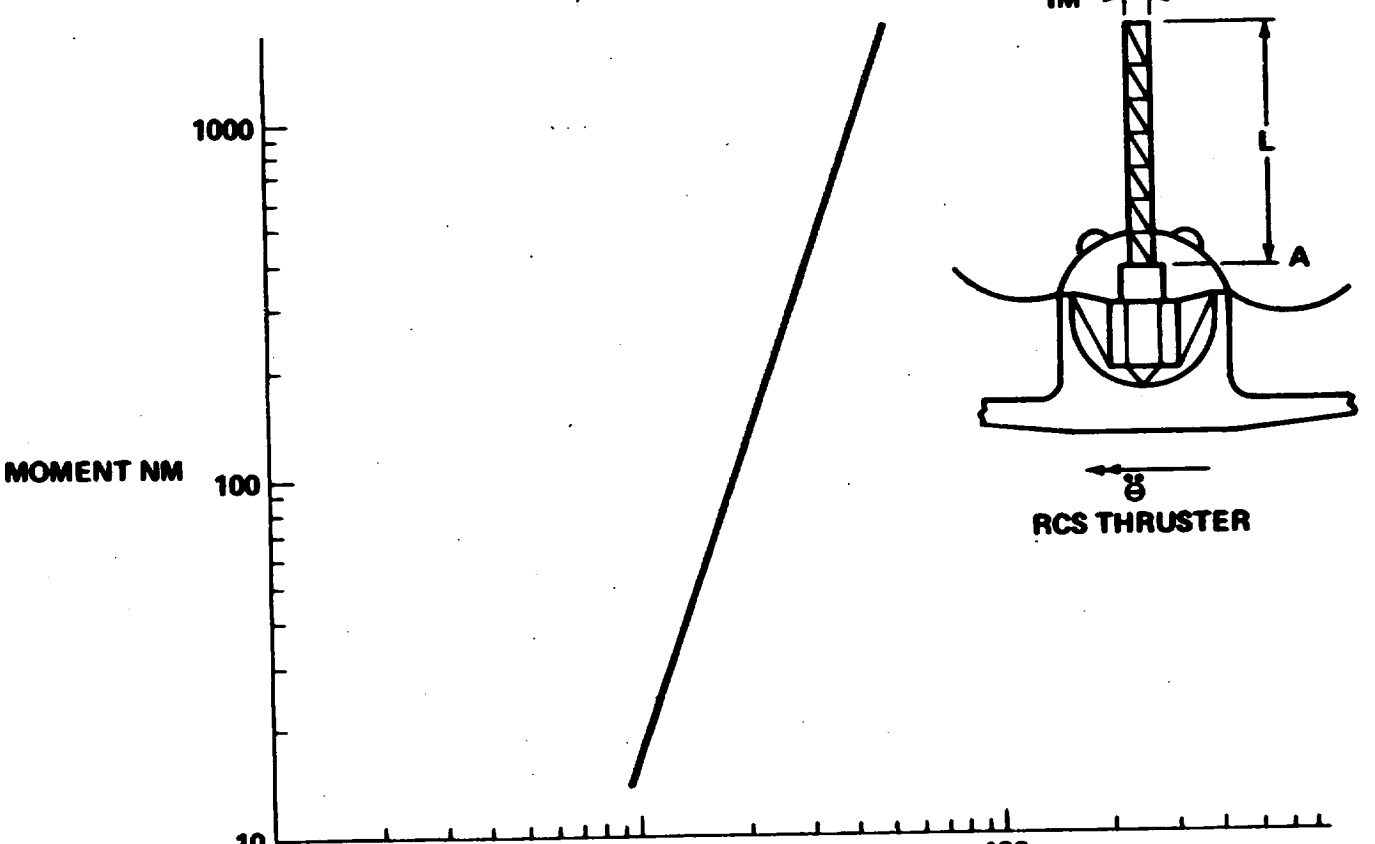
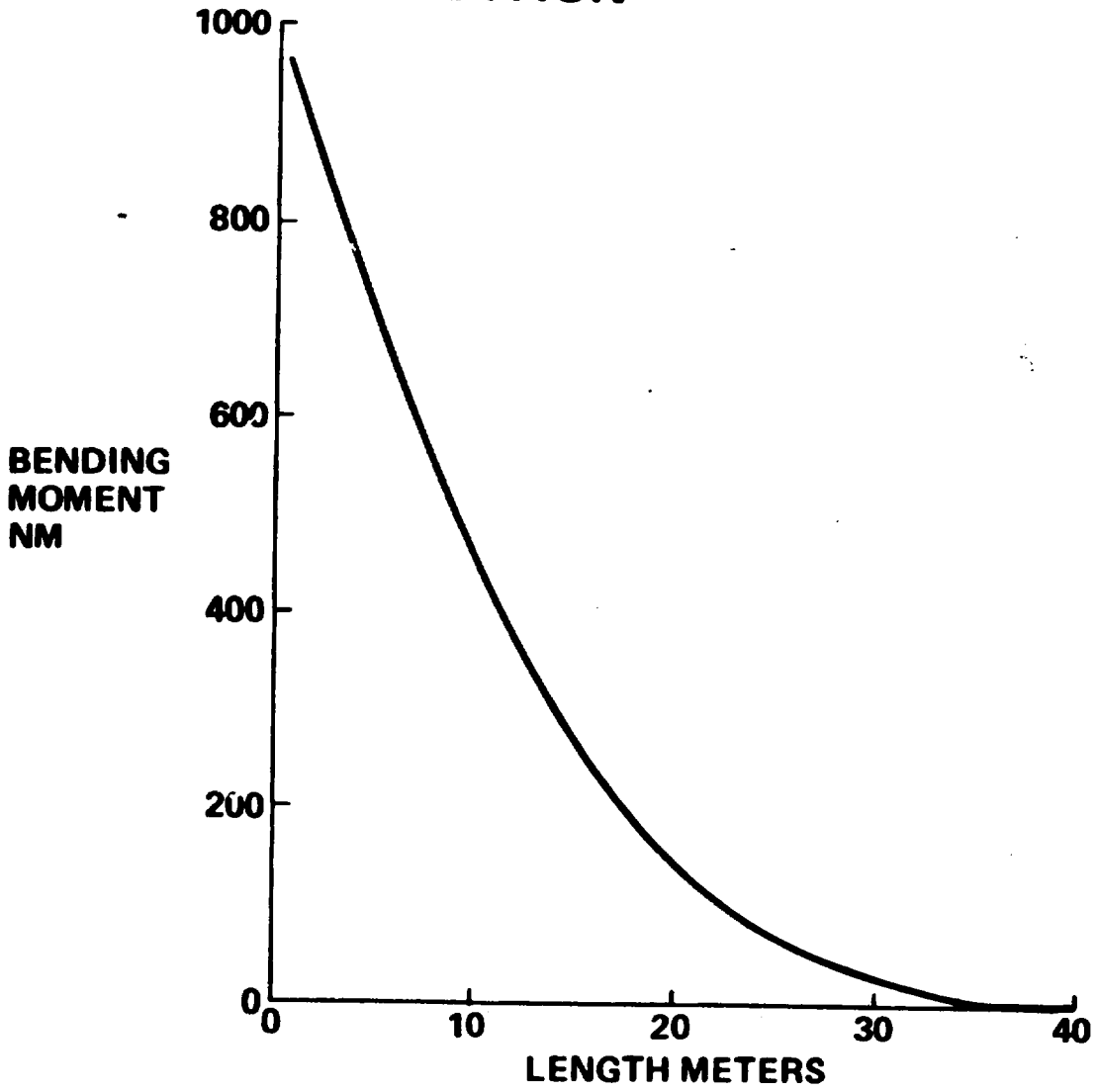
ULTIMATE BENDING MOMENT AT POINT A VS BEAM LENGTH RCS FIRING



BENDING MOMENT VS SPAN 1M X 40M BEAM-PRIMARY RCS THRUSTER FIRING CONDITION



MATERIAL COMPARISON

MATERIALS	ALUMINUM* 2219-T6	GRAPHITE/EPOXY $(0_2 \pm 45_2)$	GRAPHITE/POLYETHER-SULFONE $(0_2 \pm 45_2)$
F_{TU}, KSI	54	69	69
F_{TY}, KSI	36	–	–
F_{CY}, KSI	38	66	66
E, KSI	10.5×10^3	7.7×10^3	7.7×10^3
ρ, LB/IN.^{3}	.103	.055	.055
α, IN./IN./°F	12.4×10^{-6}	$.1 \times 10^{-6}$	$.1 \times 10^{-6}$
TEMP LIMIT, °F	350	350	440
HANDLING QUALITY DURING FAB	GOOD	• MUST BE "C" STAGE • PARTIALLY FORMED	GOOD
THERMAL COATING	FAIR APPLY COATING TO BASIC MATERIAL IN GRD PROCESS, MUST BE REMOVED FOR JOINING	EXCELLENT INCORPORATED INTO RESIN MATERIAL DURING PROCESSING GROUND	EXCELLENT INCORPORATED INTO RESIN MATERIAL DURING PROCESSING GROUND
JOINING	EXCELLENT CAN USE ANY OF THE FOLLOWING: ULTRASONIC WELD, PRESSURE WELD, MECHANICAL ATTACHMENT	POOR BONDING REQUIRES MELT & CURE	VERY GOOD ULTRASONIC WELD GIVES GOOD SIMPLE ATTACHMENT
UV DEGRADATION	EXCELLENT	NOT KNOWN	NOT KNOWN
STATE-OF-THE-ART OF APPLICATION	EXCELLENT	GOOD	NOT KNOWN

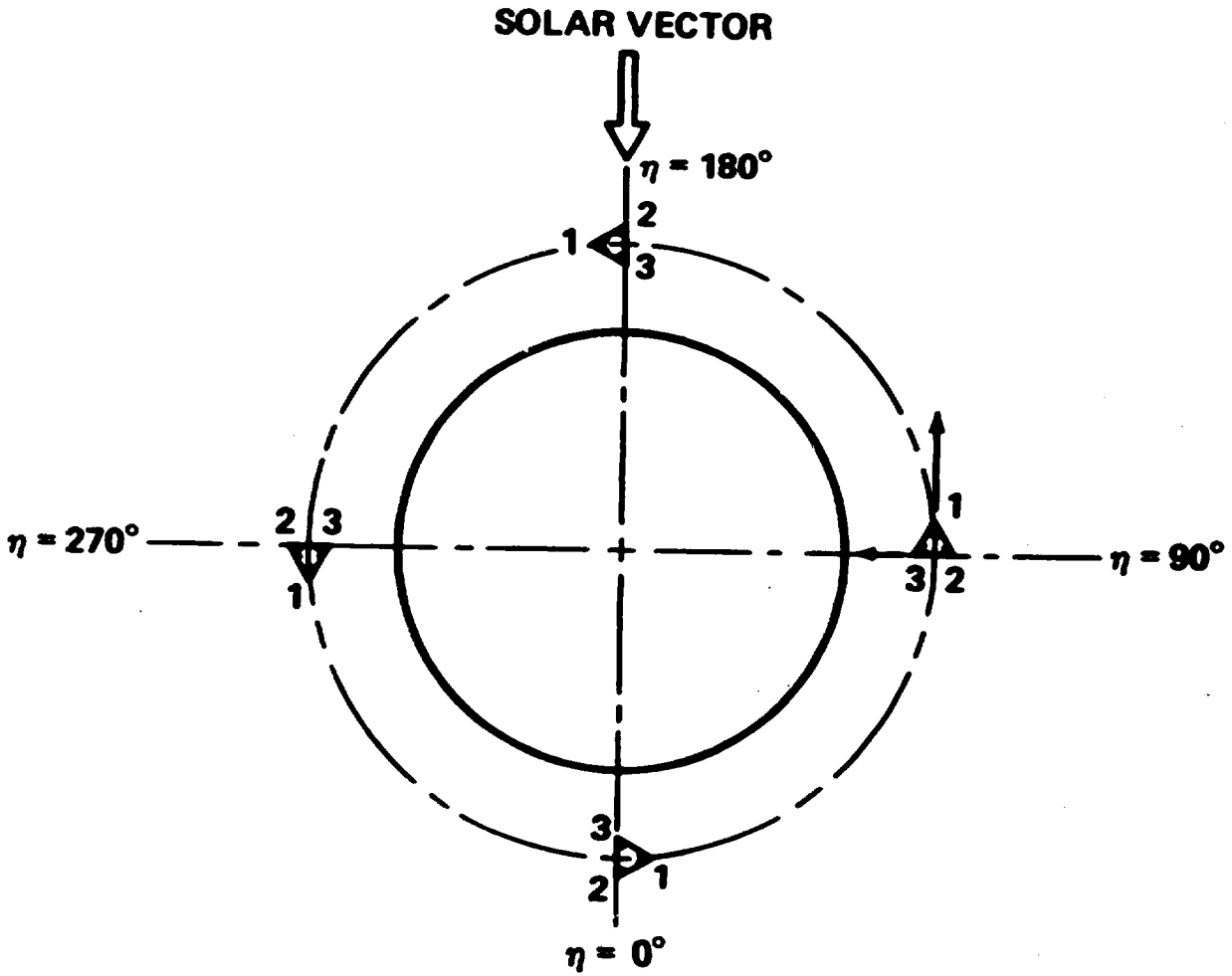
*PROPERTIES OF 2024-T3 AND 6061-T6 APPROXIMATELY THE SAME

2105-092W

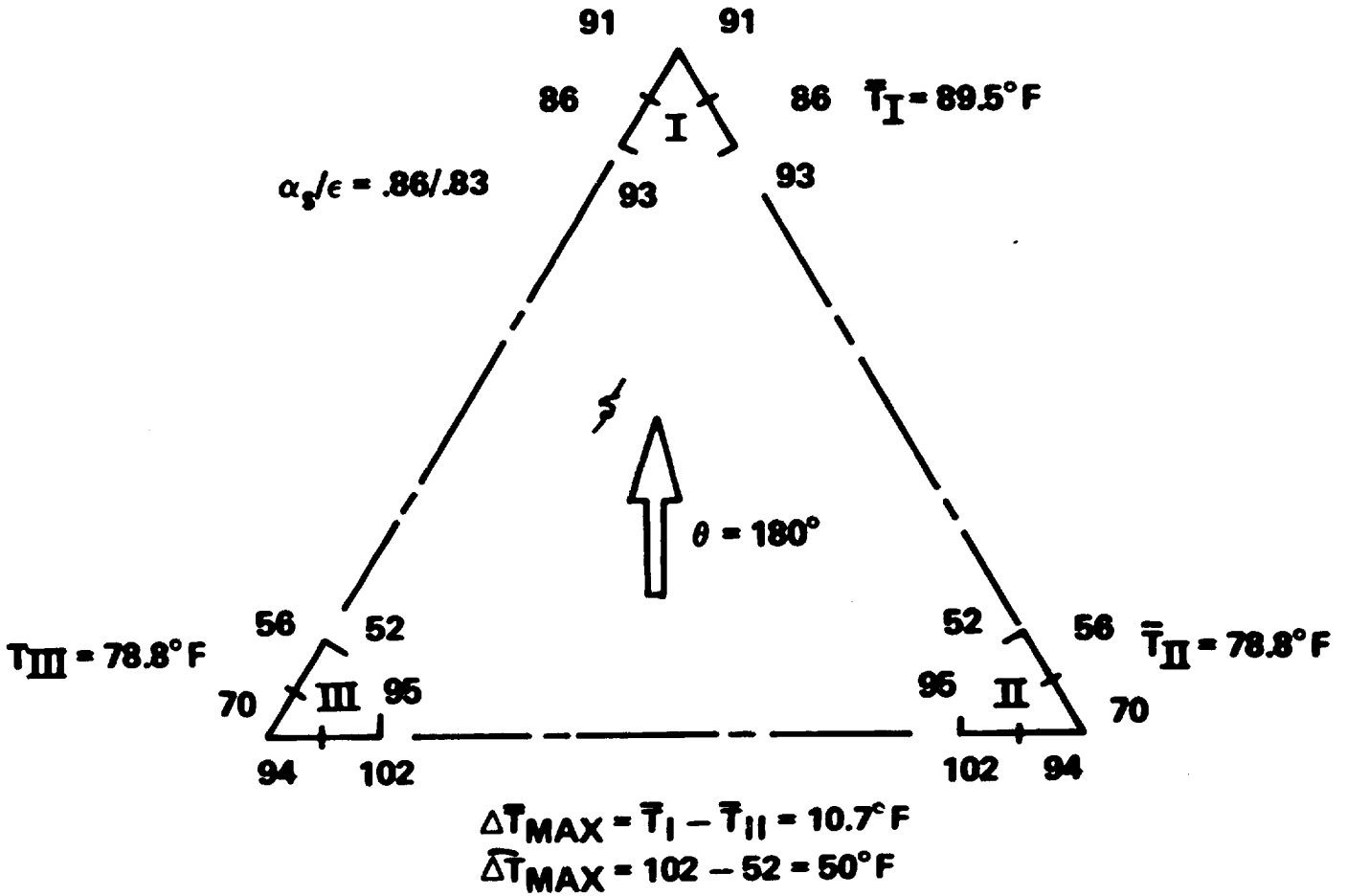
CANDIDATE THERMAL COATINGS

- BLACK ANODIZE MIL A-8625
  - ELECTROLYTICALLY PRODUCED DYED OXIDE COATING
  - THICKNESS .01 TO .1 MILS
  - ABSORPTANCE TO EMITTANCE RATIO < 1.00
- SPRAY PAINTS
  - POLYURETHANE
  - FLUOROCARBON
  - THICKNESS APPROX .8 TO 1 MIL
  - $\alpha = .96, \epsilon = .91$

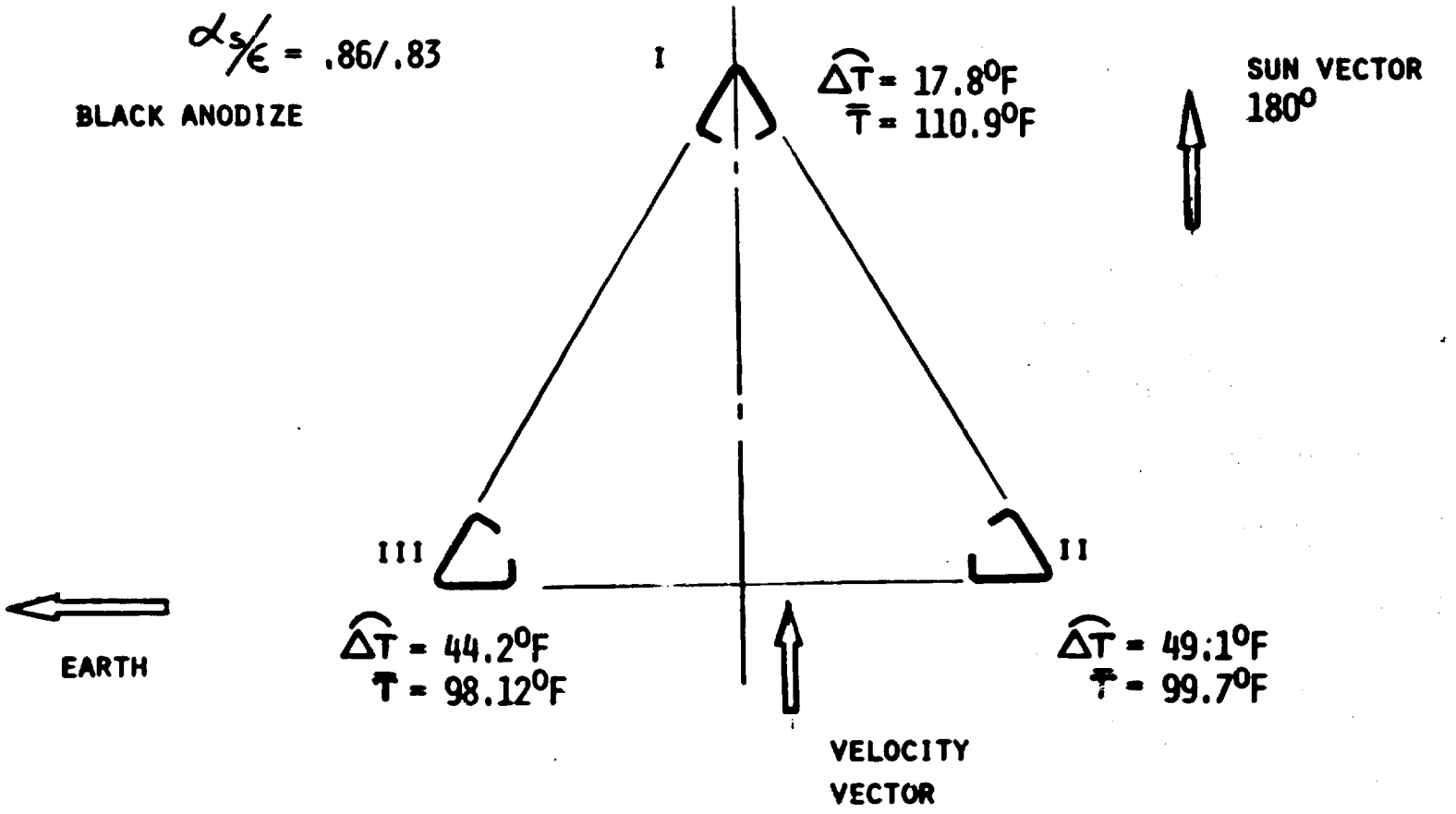
BEAM ORBITAL ORIENTATION



TEMPERATURE DATA $\theta = 180°$



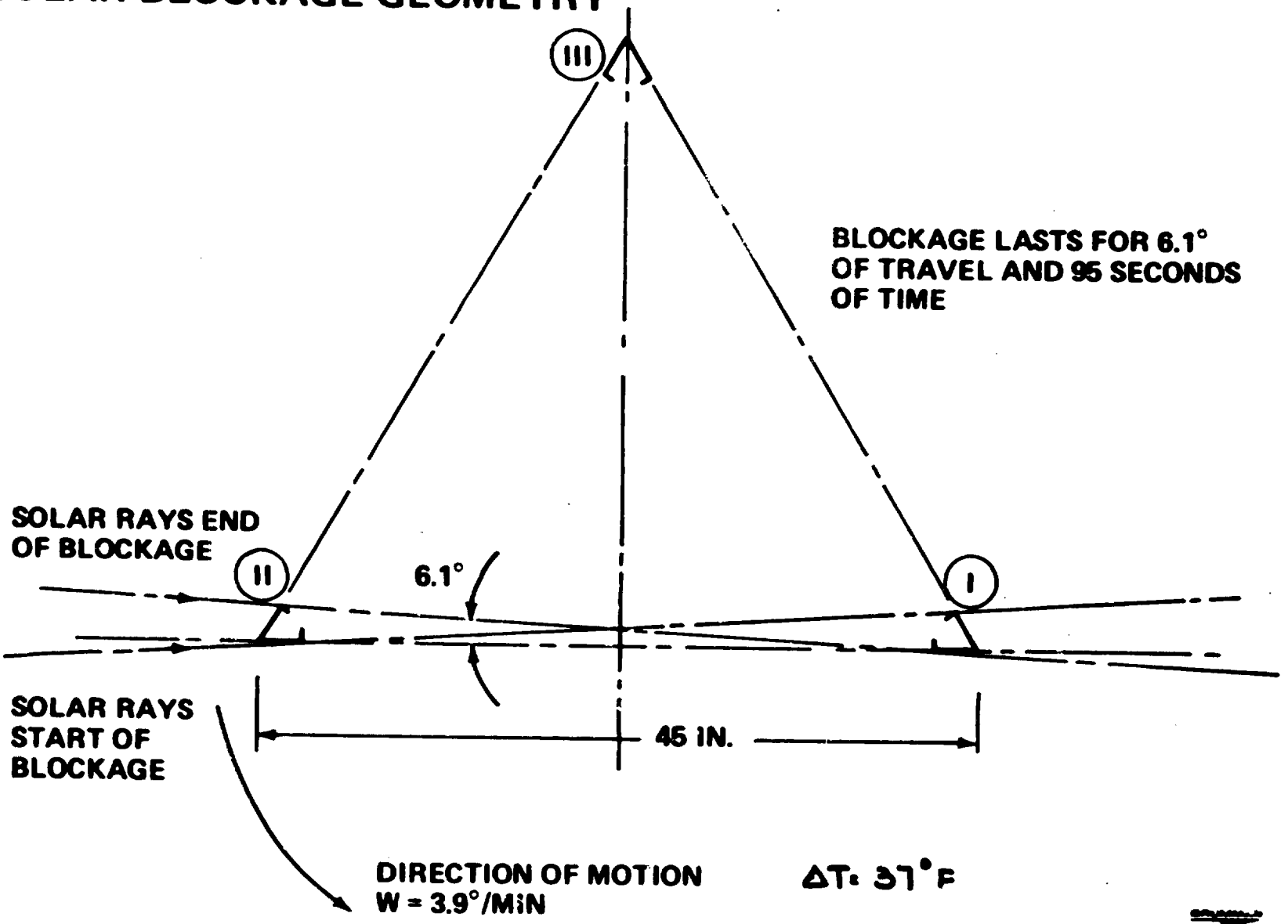
ORBITAL TEMPERATURE
RESPONSE



$\Delta\hat{T}$ = 49.1°F MAX TEMP DIFFERENCE INTRIANGLE

$\Delta\bar{T}_{Av}$ = 12.8°F MAX TEMP DIFFEREN CE BETWEEN TRIANGLES AREA WEIGHTED

SOLAR BLOCKAGE GEOMETRY

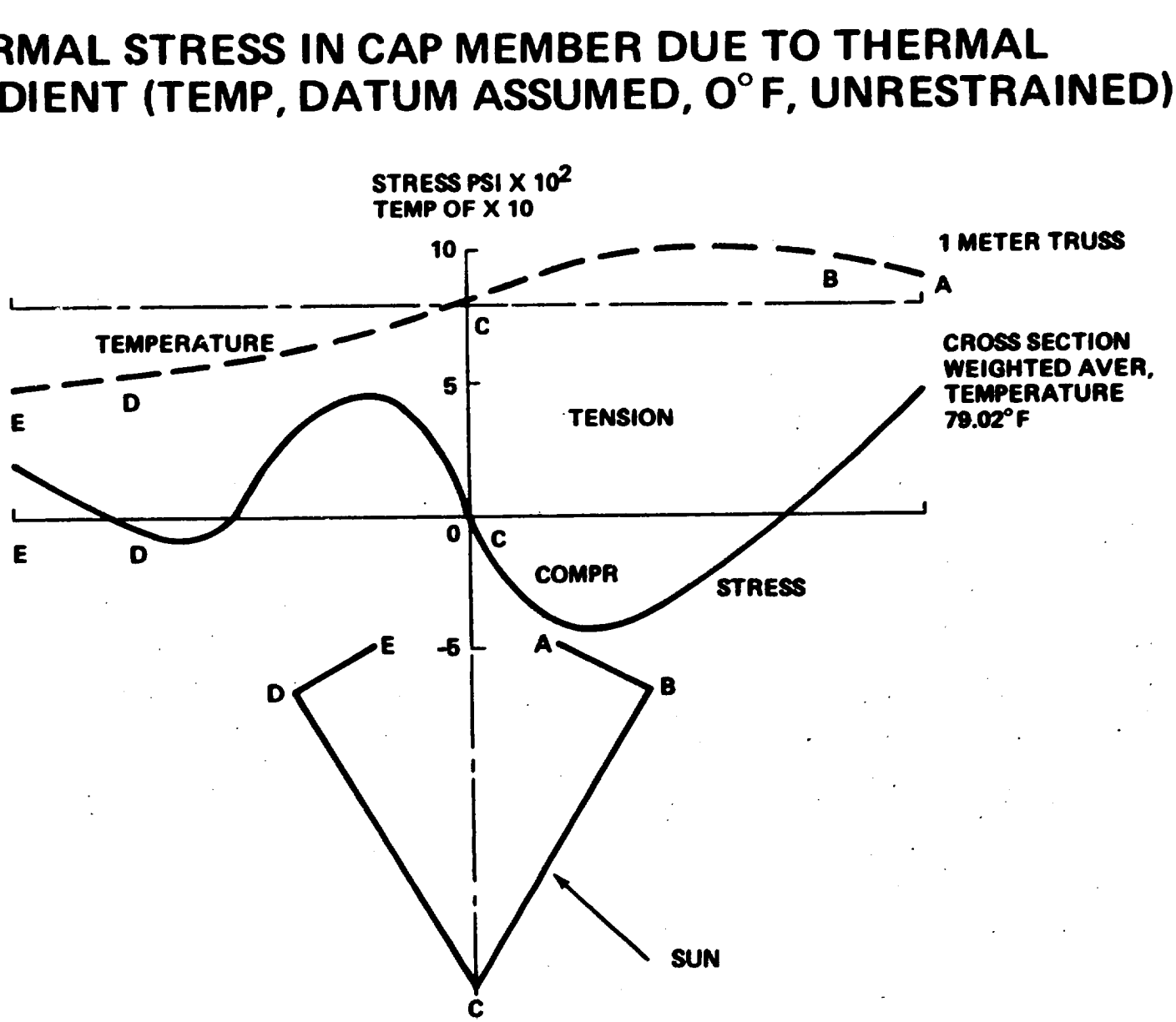


2105-102W

DESIGN CONDITION I

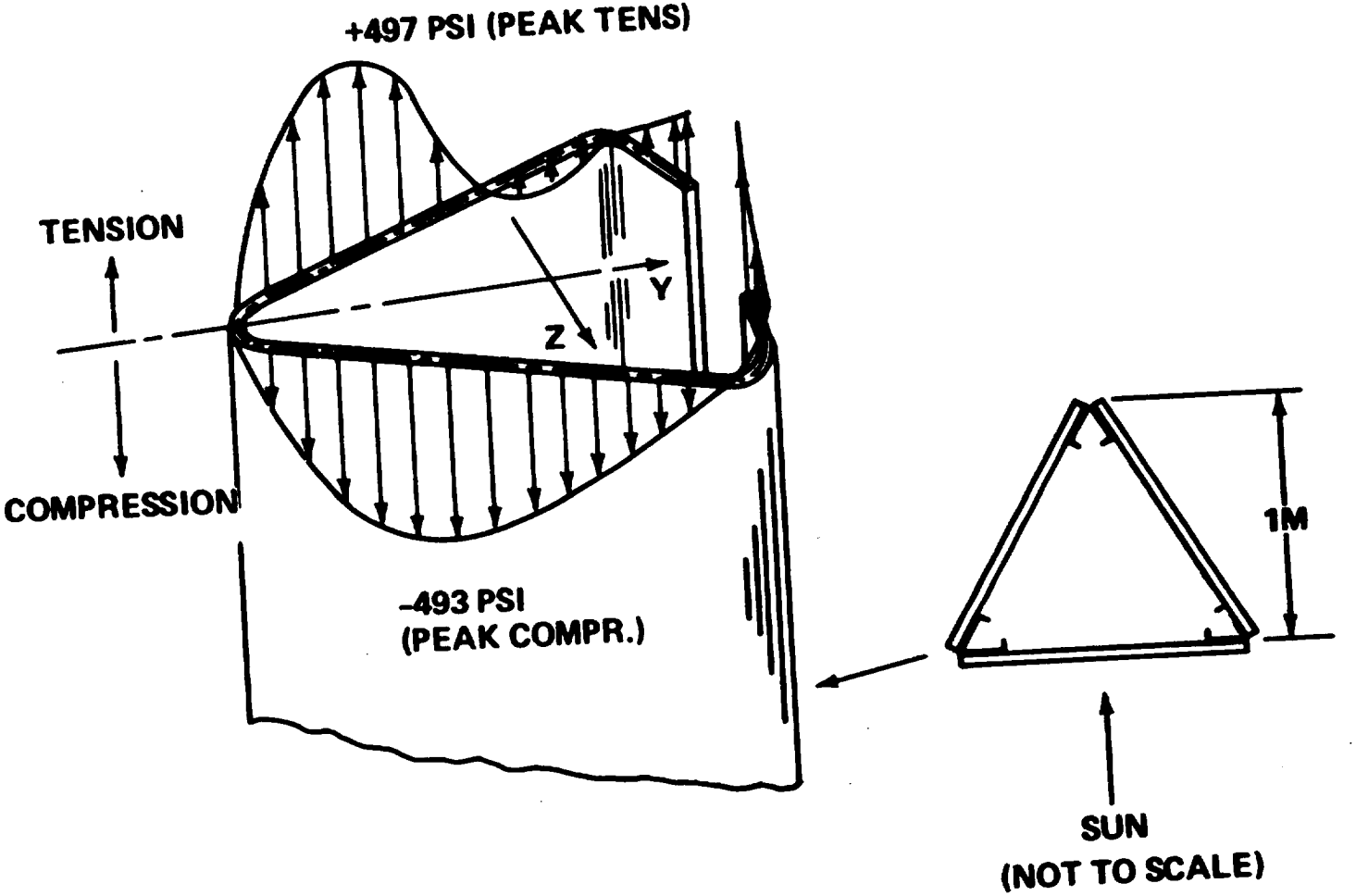
- THERMAL STRESSES
- FREQUENCIES AND MODE SHAPES

THERMAL STRESS IN CAP MEMBER DUE TO THERMAL GRADIENT (TEMP, DATUM ASSUMED, O° F, UNRESTRAINED)

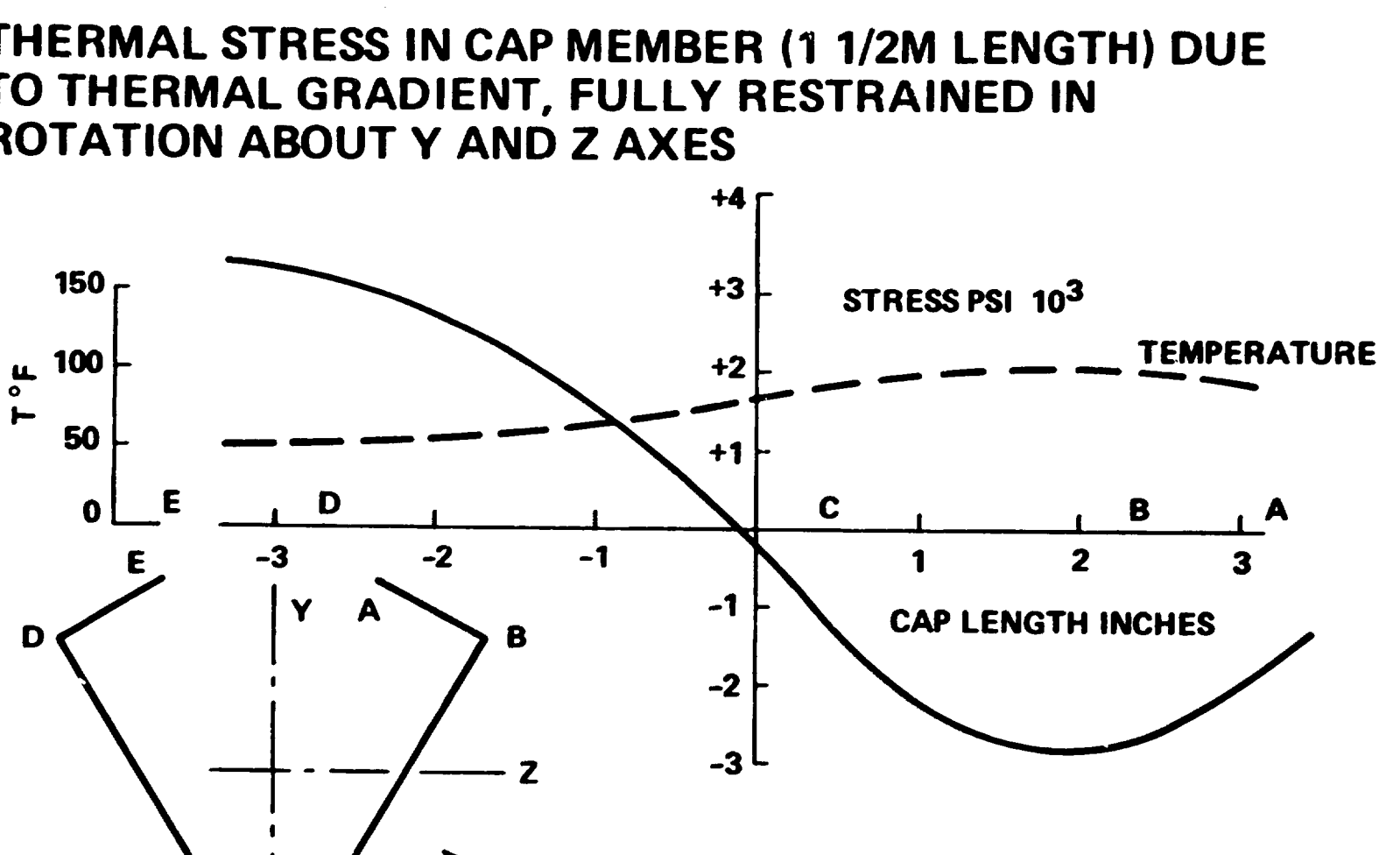


2105-86W

THERMAL STRESS IN CAP 1 METER TRUSS

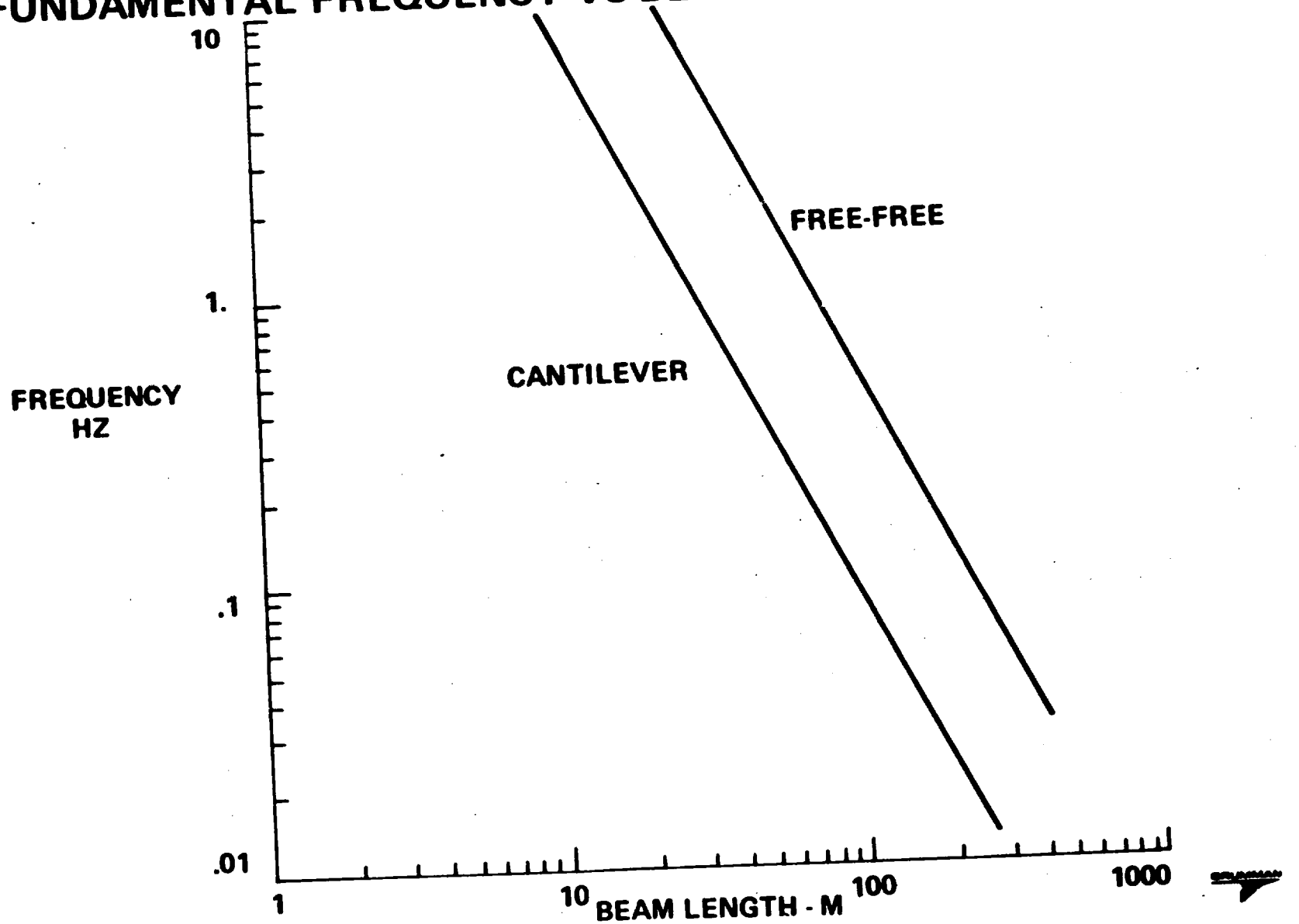


THERMAL STRESS IN CAP MEMBER (1 1/2M LENGTH) DUE TO THERMAL GRADIENT, FULLY RESTRAINED IN ROTATION ABOUT Y AND Z AXES



2105-085W

FUNDAMENTAL FREQUENCY VS BEAM LENGTH 1 METER BEAM



2105-101W

1M X 40M BEAM SHUTTLE-MOUNTED MODES

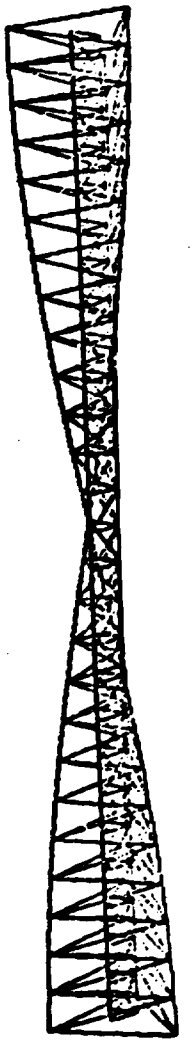
1ST LATERAL
BENDING .57 HZ
(+X)

1ST LATERAL
BENDING .57 HZ
(+ Y)

2ND LATERAL
BENDING
3.5 HZ

1M X 40M BEAM FREE-FREE MODES

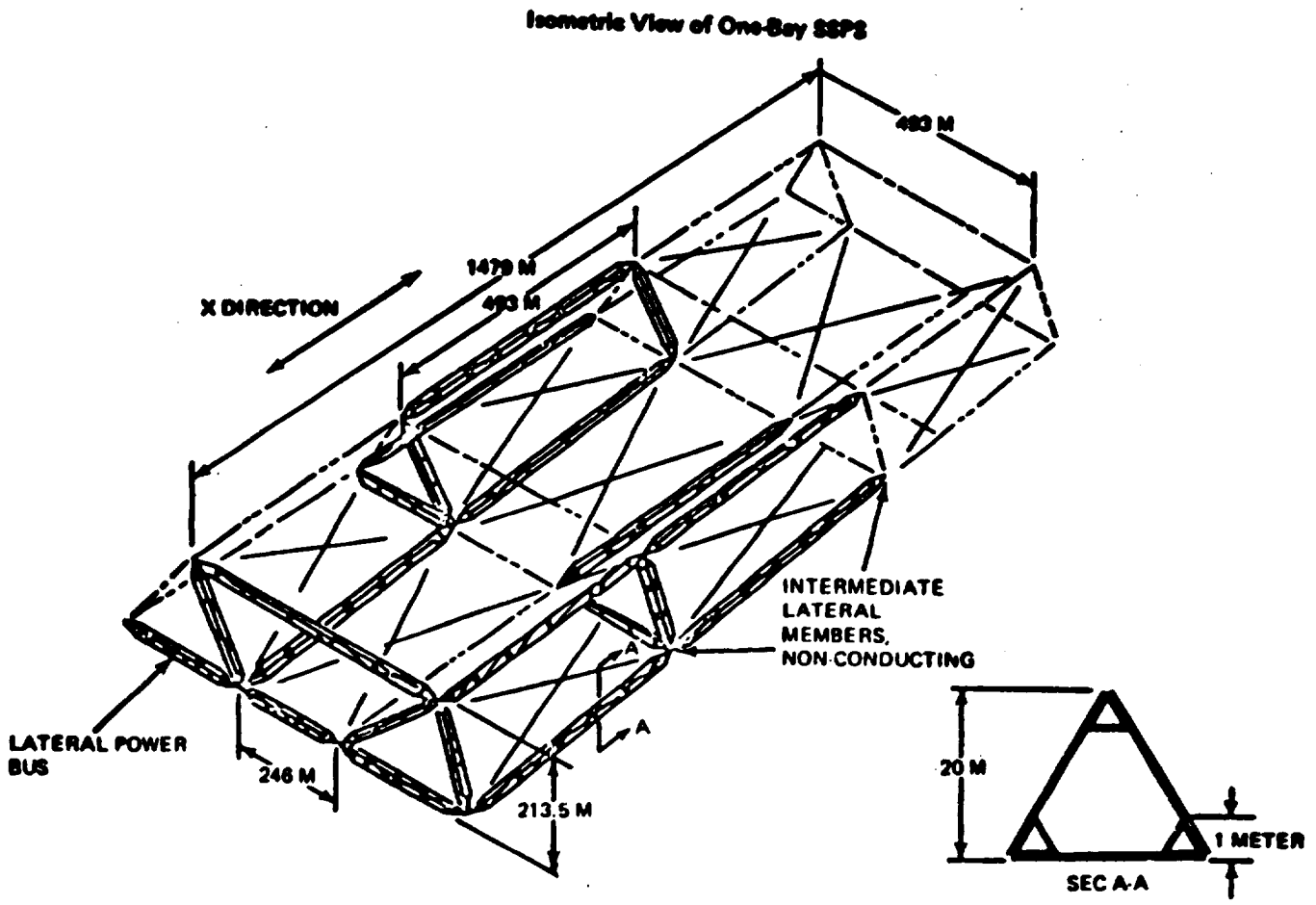
1ST LATERAL
BENDING 3.6 HZ



1ST TORSION
7.6 HZ

DESIGN CONDITION II

- LOADS DATA
- TEMPERATURE DATA


Isometric View of One-Bay SSPS
493 M
1479 M
493 M
X DIRECTION
INTERMEDIATE
LATERAL
MEMBERS,
NON-CONDUCTING
LATERAL POWER
BUS
246 M
213.5 M
A
A
20 M
1 METER
SEC A-A

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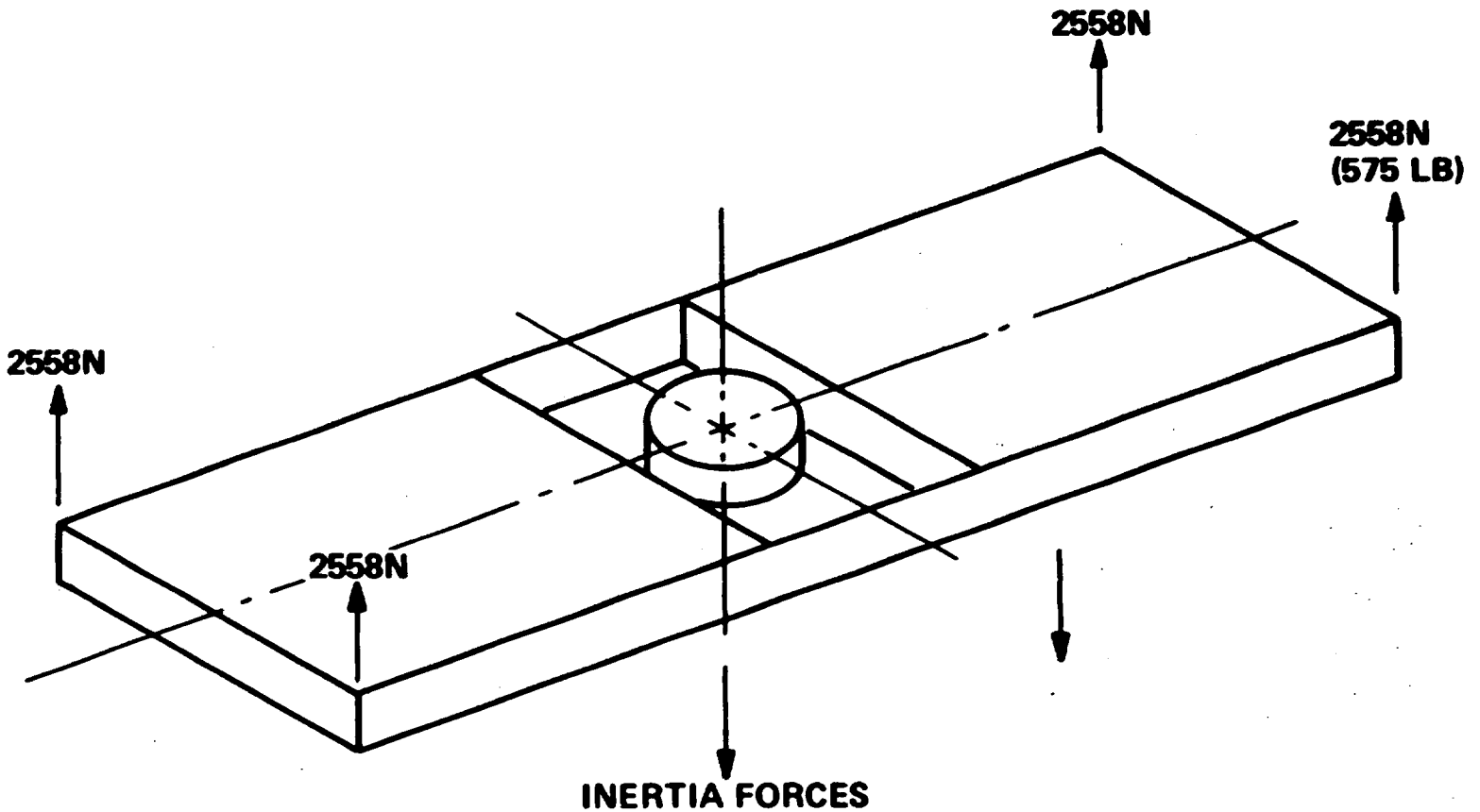
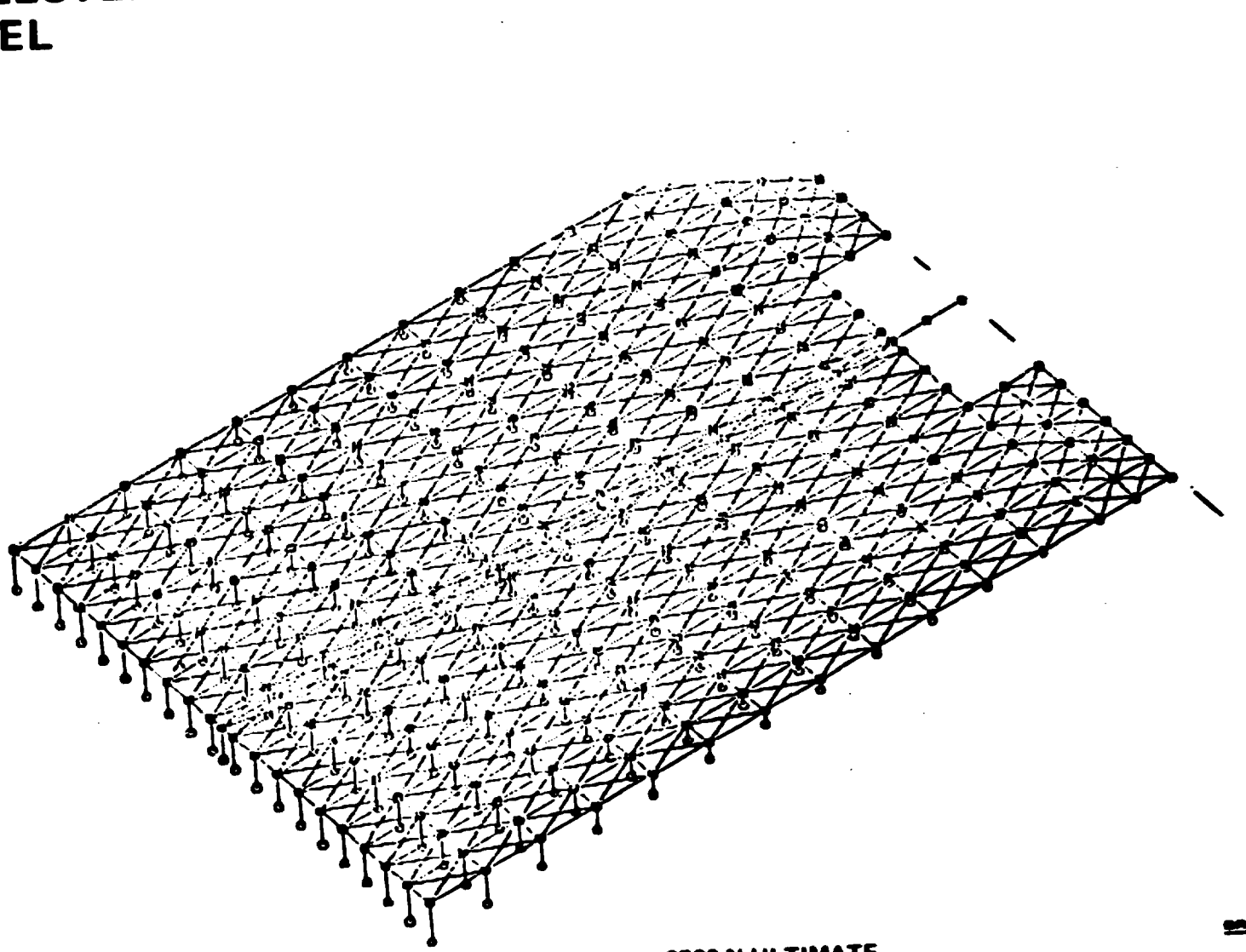
DESIGN CONDITION II – SSPS STATIONKEEPING MANEUVER



MAXIMUM APPLIED THRUSTER FORCES INCREASED BY DYNAMIC MAGNIFICATION FACTOR = 2.0, FACTOR OF SAFETY = 1.40

2105-84W

DEFLECTED SHAPE DUE TO TIP LOAD-STRUCTURAL MODEL

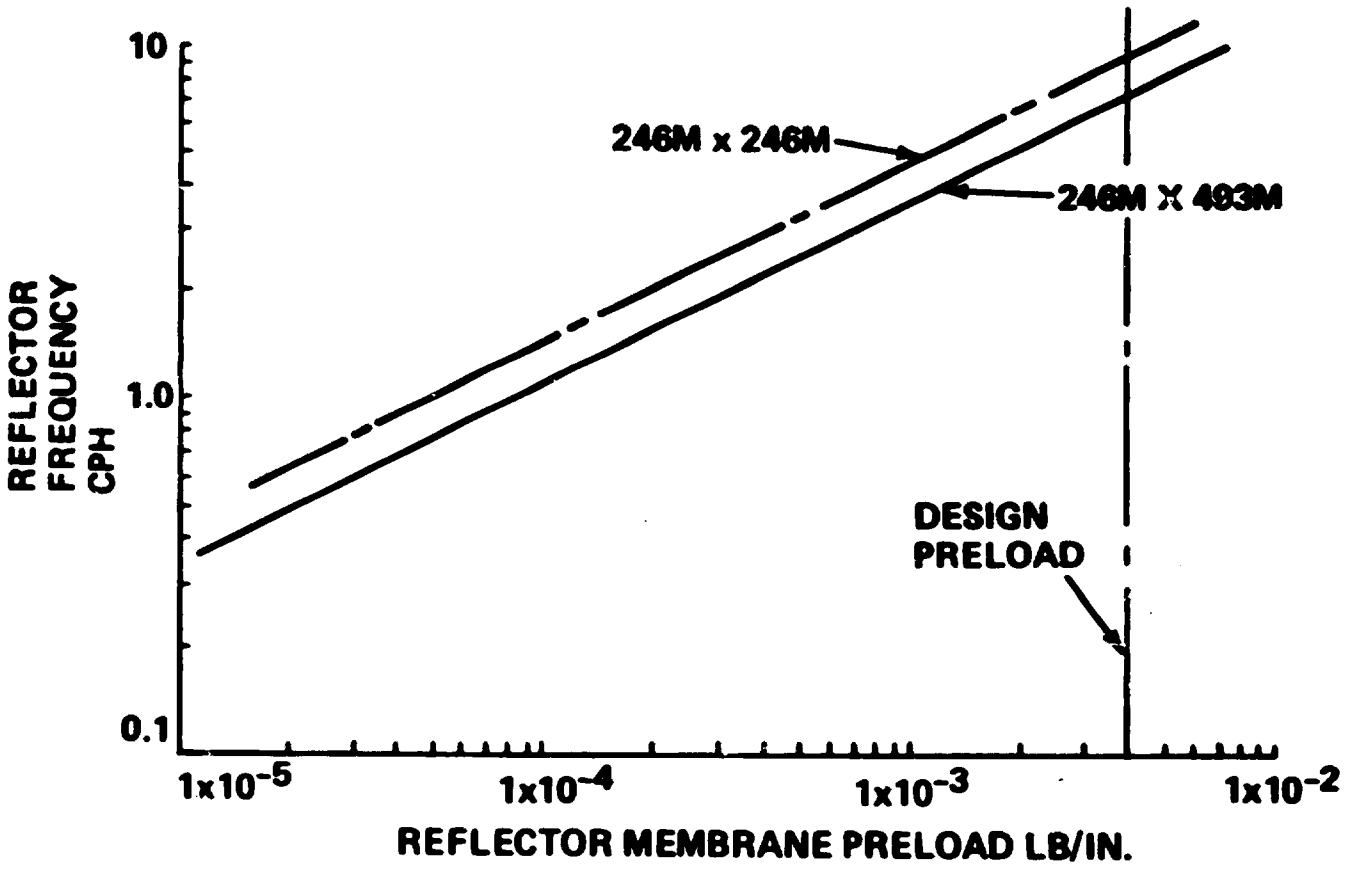


PEAK MEMBER LOAD = −3530 N ULTIMATE

SOLAR REFLECTOR PRELOAD REQUIREMENTS

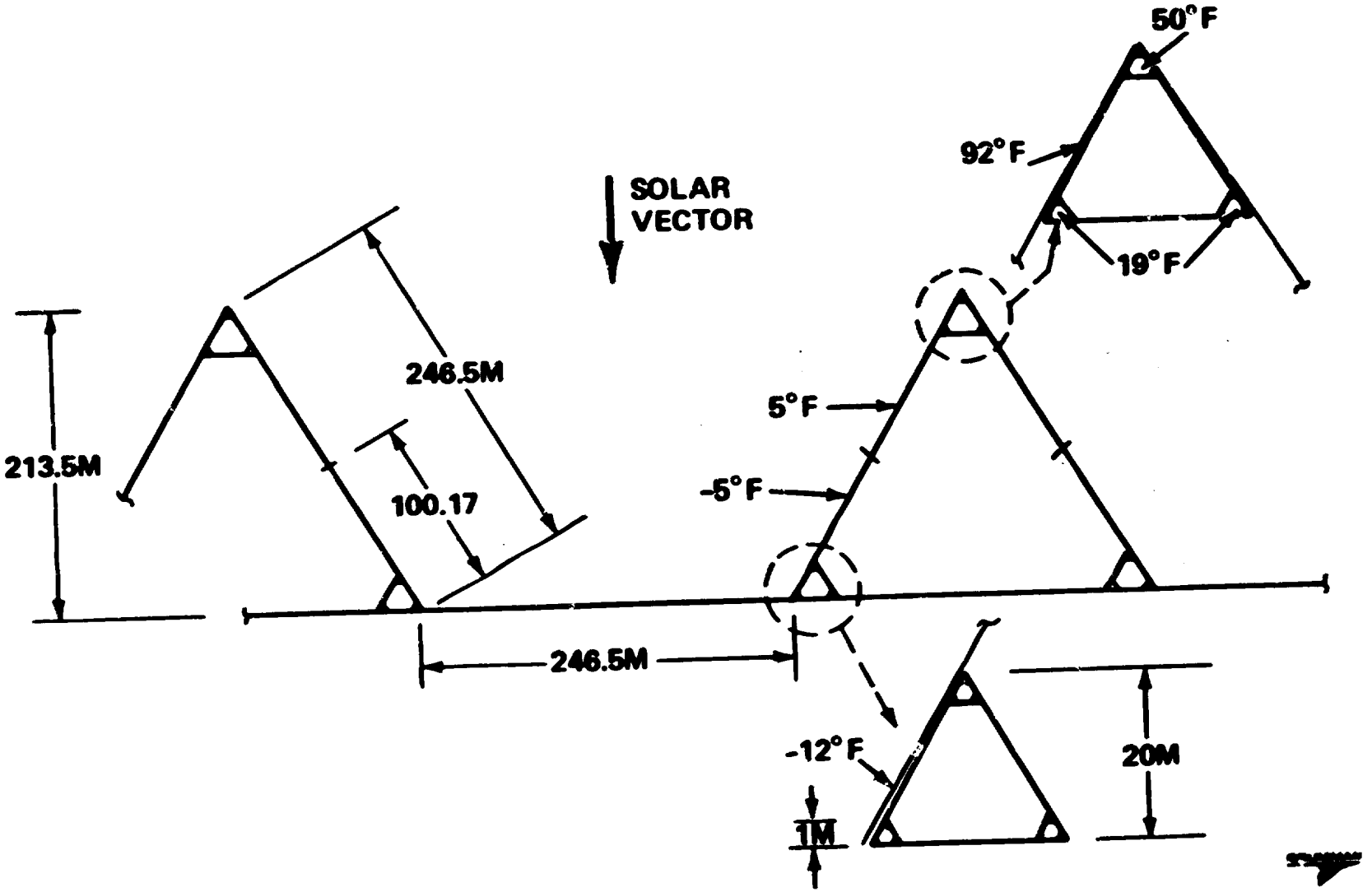
- REFLECTOR PRELOAD IS SIGNIFICANT DRIVER FOR BEAM DESIGN
- PRELOAD EVALUATED FOR:
  - THERMAL EXCURSIONS
  - SOLAR RADIATION PRESSURE
  - ROTATIONAL ACCELERATIONS
  - NATURAL FREQUENCY

SOLAR REFLECTOR NATURAL FREQUENCY VS PRELOAD



2105-095W

SSPS STEADY STATE TEMPERATURE DISTRIBUTION FULL SUN



2105-078W

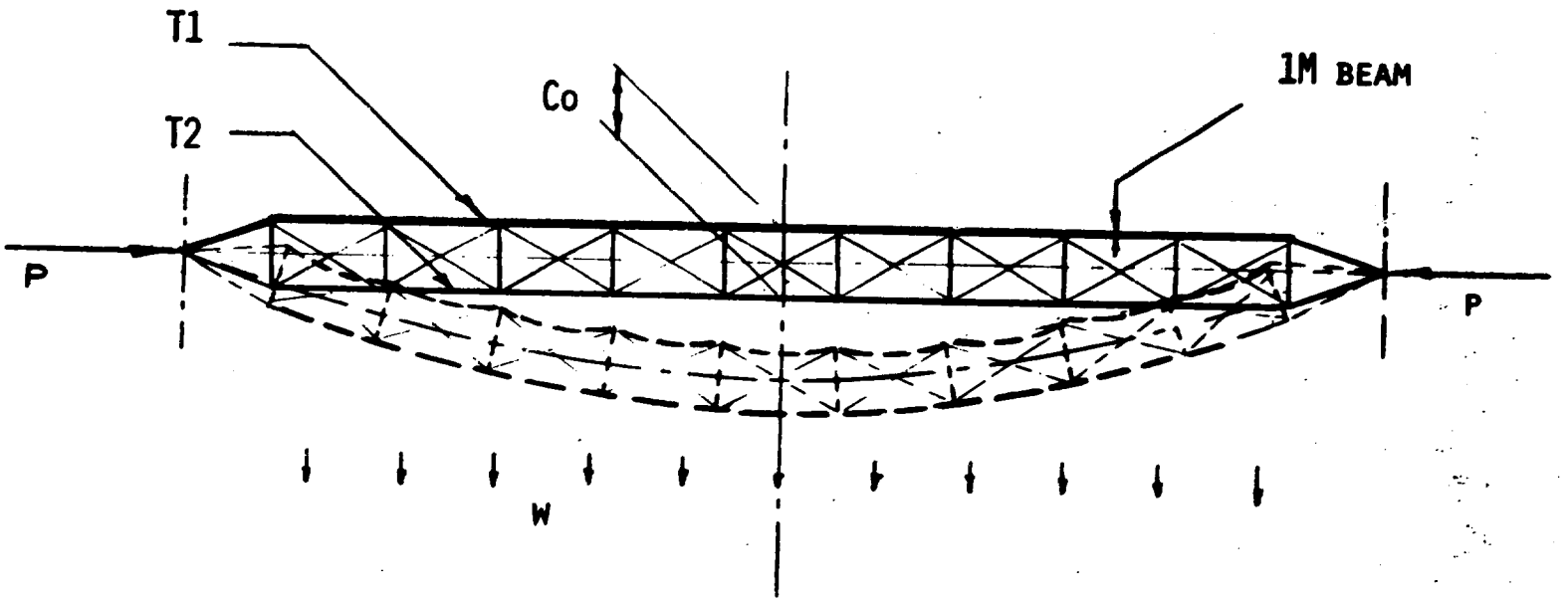
DESIGN CONDITION II

SSPS 1M X 40M BEAM CRITICAL CAP LOAD FUNCTION OF FOLLOWING:

- AXIAL LOAD DUE TO BENDING – STATIONKEEPING
- REFLECTOR PRELOAD
- MANUFACTURING MISALIGNMENT OF 20M X 493M BEAM
- THERMAL GRADIENT/DEFLECTION OF 20M X 493M BEAM
- MANUFACTURING MISALIGNMENT OF THE 1M X 40M BEAM
- THERMAL GRADIENT/DEFLECTION OF THE 1M X 40M BEAM

DESIGN LOADING CONDITION

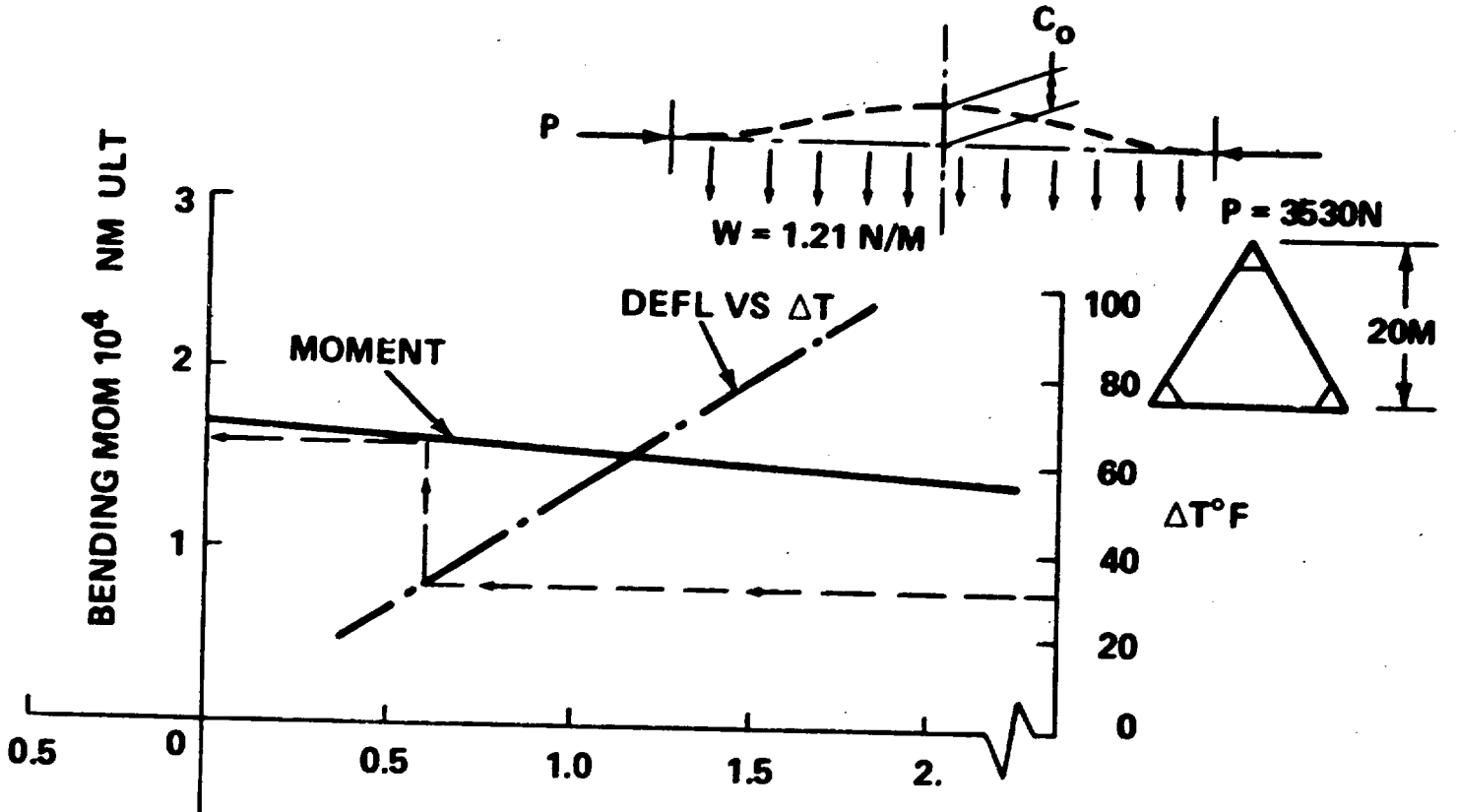
20M X 493M BEAM



P = 3530 N

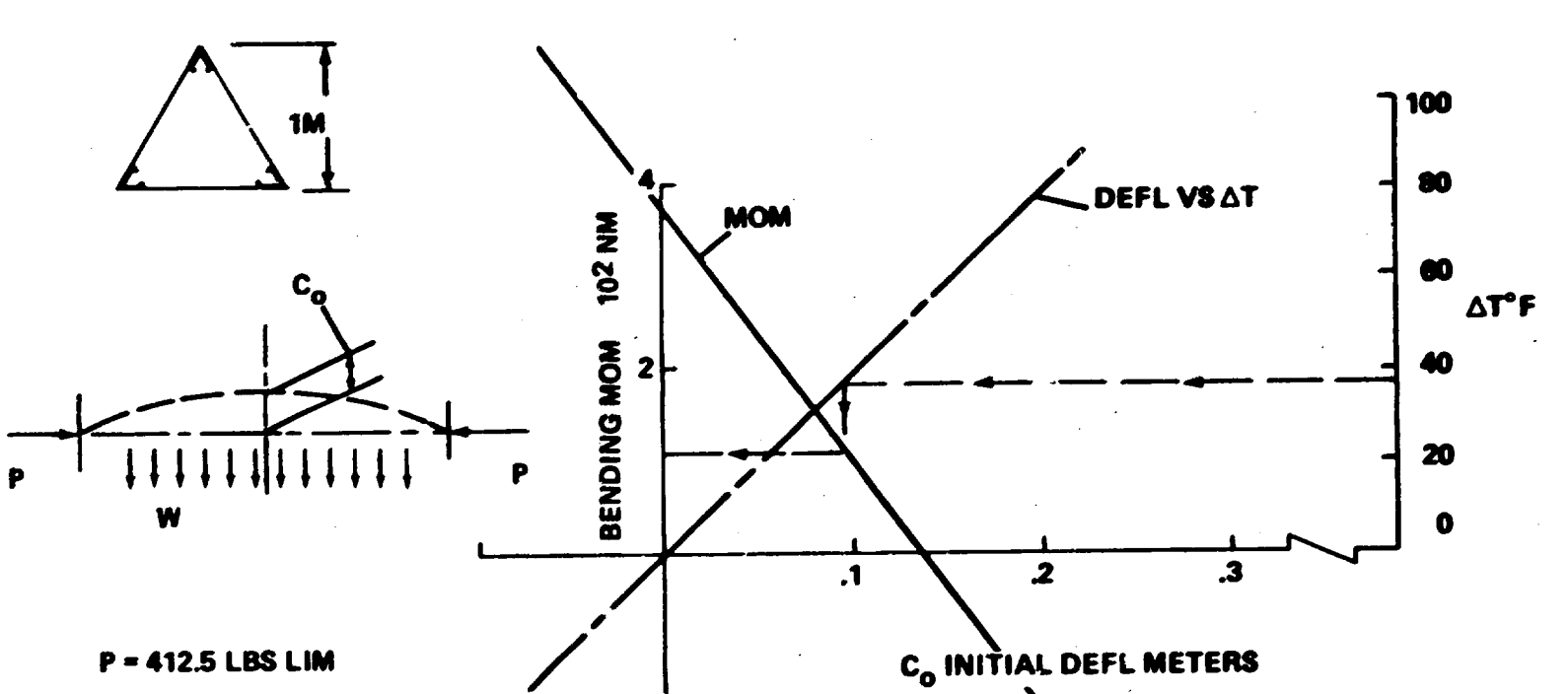
W = 1.21 N/M LIMIT

BENDING MOMENT DUE TO COMBINED LOADS AND INITIAL DEFL 20M X 493M BEAM



2105-083W

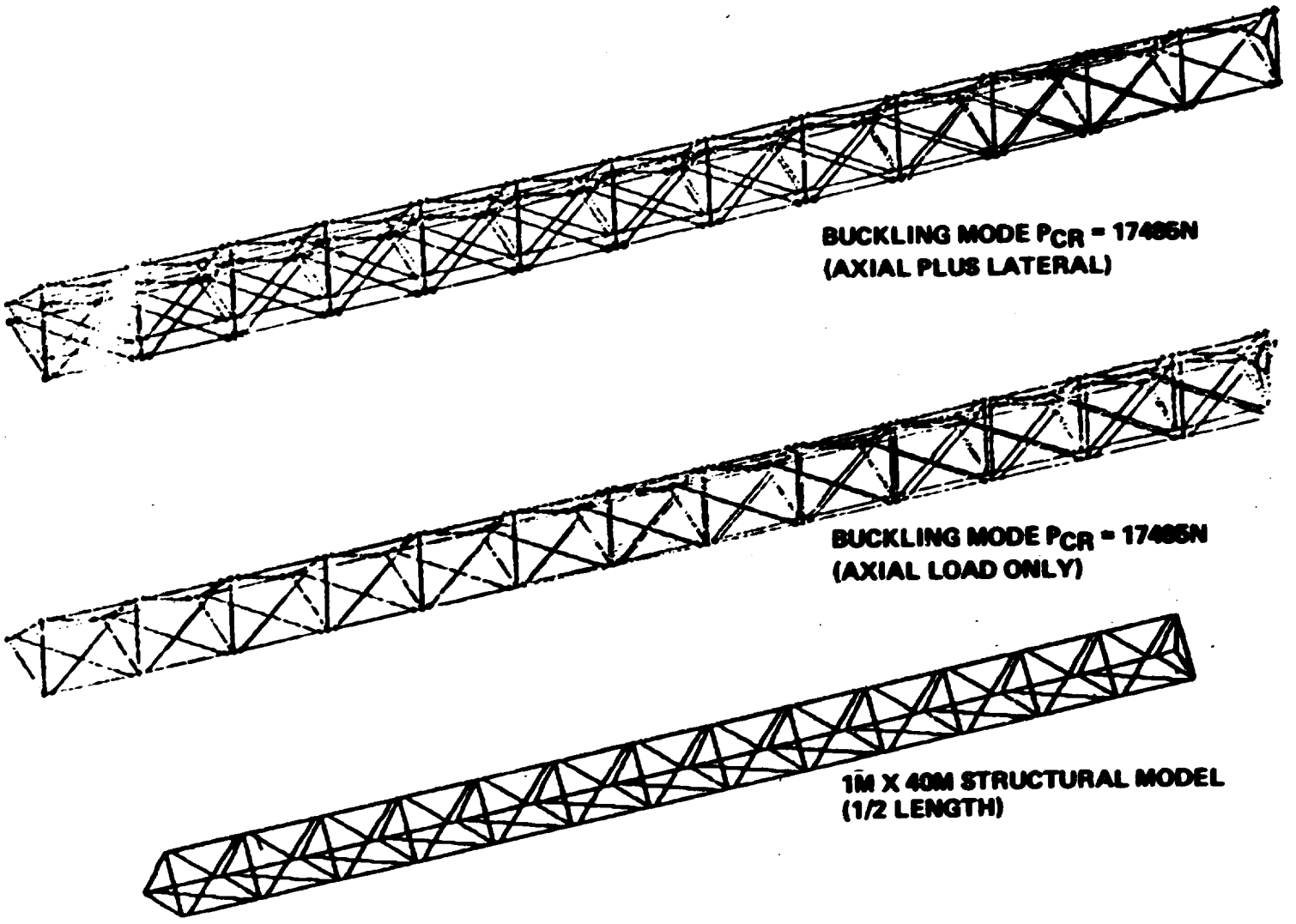
BENDING MOMENT DUE TO COMBINED LOADS AND INITIAL DEFL 1M X 40M BEAM



BEAM FAILURE MODES

- 40 M EULER INSTABILITY
- CAP LOCAL CRIPPLING
- 1½ M CAP TORSION/FLEXURE INSTABILITY

OVERALL STABILITY OF 1M X 40M BEAM



2106-079W

MAXIMUM BEAM CAP STRESSES
1M X 40M BEAM

- **DESIGN CONDITION I:**
  - **COMPRESSION STRESS**
    - **APPLIED LOADS -- 2505 PSI**
    - **THERMAL GRADIENT -- 690 PSI**
    - **TOTAL -- 3195 PSI**

- **DESIGN CONDITION II (SSPS):**
  - **COMPRESSION STRESS**
    - **APPLIED LOADS -- 2272 PSI**
    - **THERMAL GRADIENT -- 690 PSI**
    - **TOTAL -- 2962 PSI**

  - **ALLOWABLE AVERAGE COMPR STRESS BASED ON STATIC TEST 4421 PSI**

ALLOWABLE MANUFACTURING MISALIGNMENT
1M X 40M BEAM

DESIGN CONDITION II:

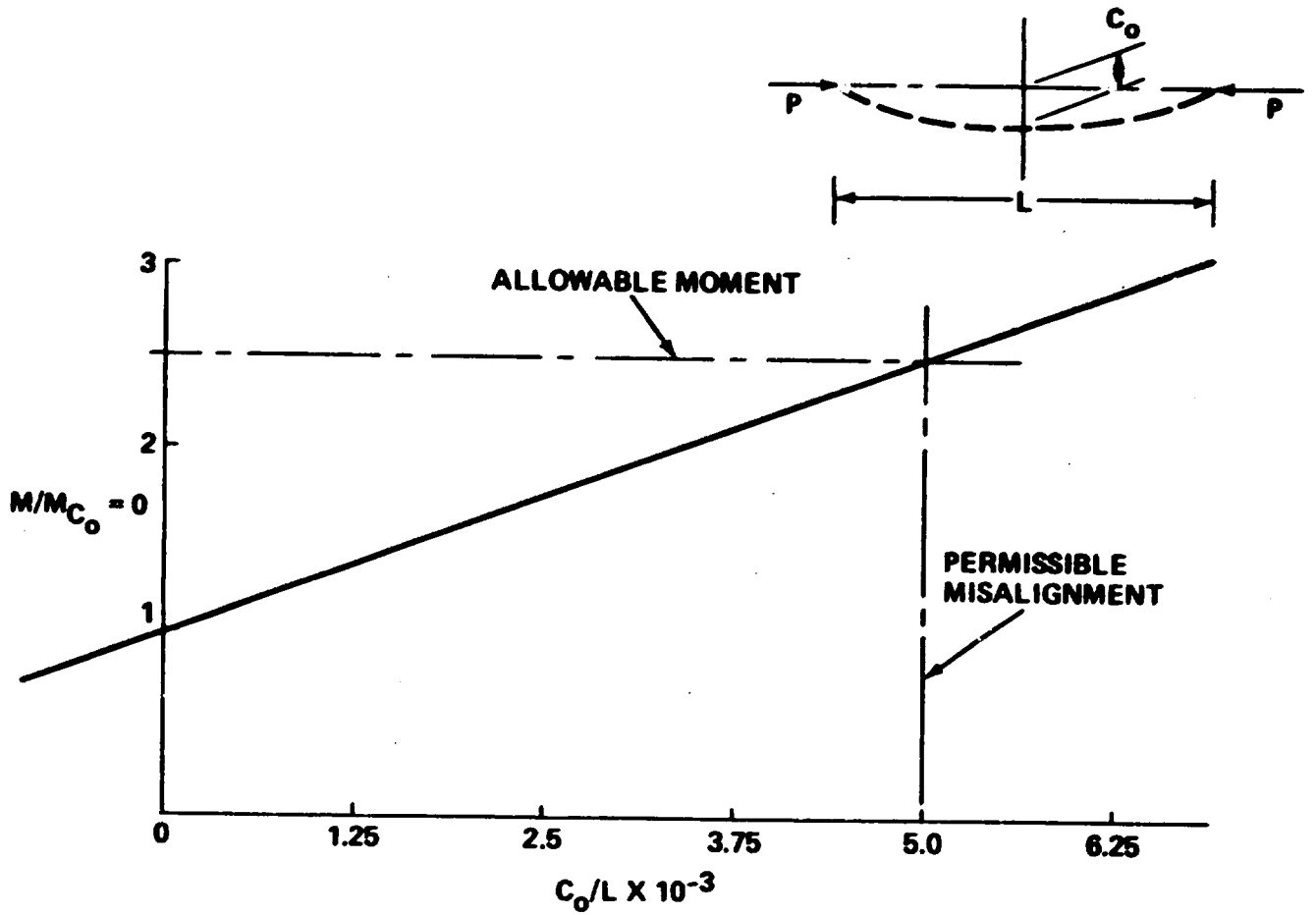
ULTIMATE CAP LOAD: -856N (-192.5 LBS)

ALLOWABLE CAP LOAD: -1868N (-420 LBS)

PERMISSIBLE MOM: 977NM (8645 IN LBS)

ALLOWABLE MISALIGNMENT C_o = .21 METERS

EFFECT OF MANUFACTURING MISALIGNMENT ON BEAM MOMENT (APPLIES IN X-Z PLANE ONLY)*

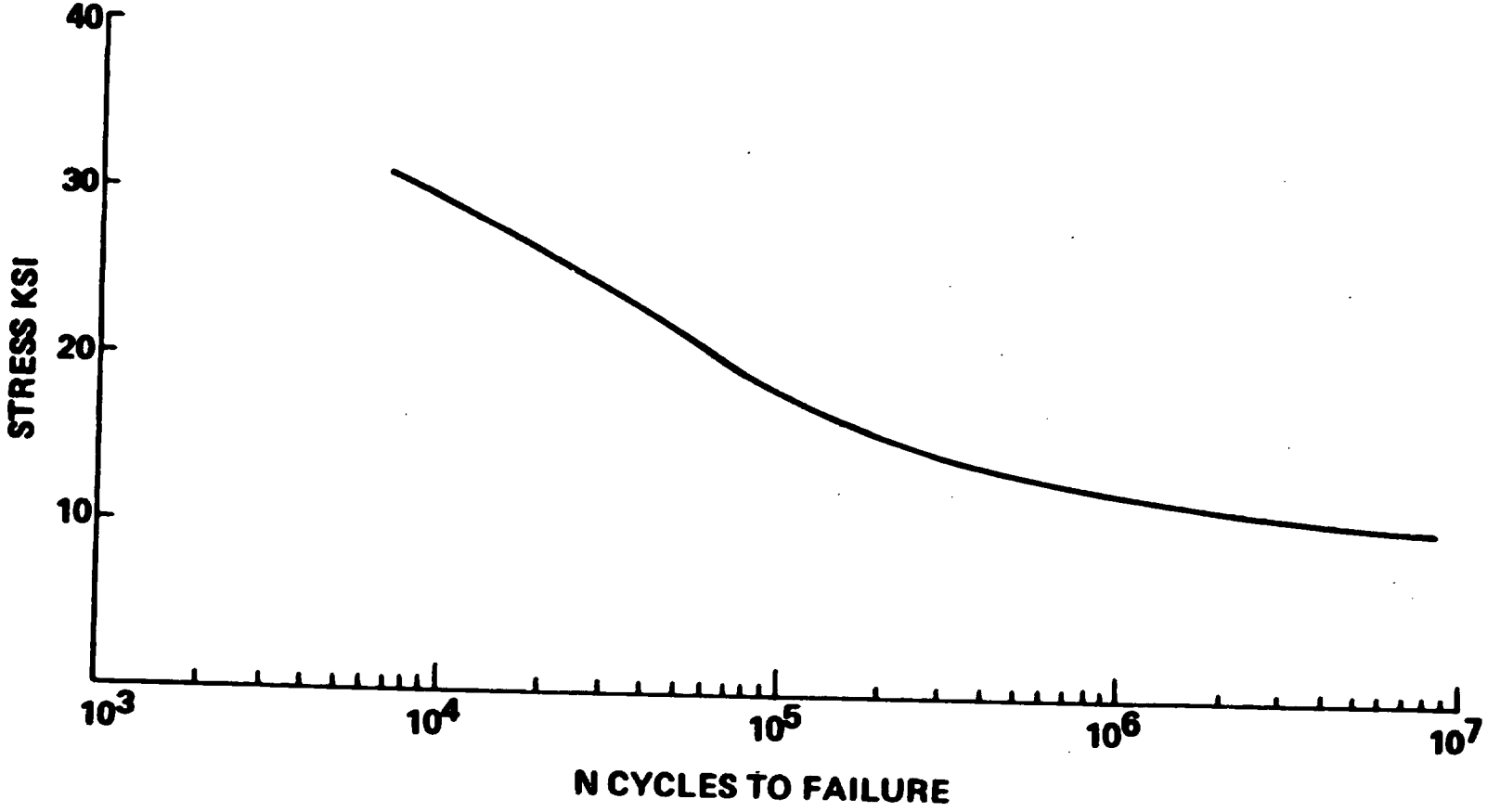


*MISALIGNMENT IN X-Y PLANE INDUCES TORSION

FATIGUE

- SSPS
  - 30 YEAR LIFE REQUIREMENT
  - GEOSYNCHRONOUS ORBIT – ENTERS AND EXISTS ECLIPSE PHASE TWICE EACH YEAR FOR 45 DAY PERIOD
  - USE SCATTER FACTOR OF 4.0
  - NUMBER OF THERMAL STRESS CYCLES 21600
  - NUMBER OF MECHANICAL STRESS CYCLES – TBD
  - MAXIMUM STRESS (TENSION) + 6752 PSI
  - ENDURANCE LIMIT APPROX 11000 PSI

FATIGUE DATA S-N CURVE NOTCHED $K_T = 2.0$; 2024 – T3



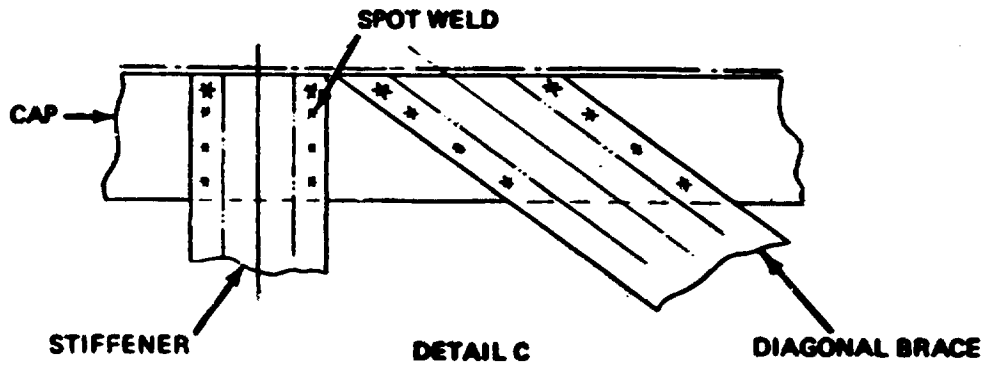
2105-91W

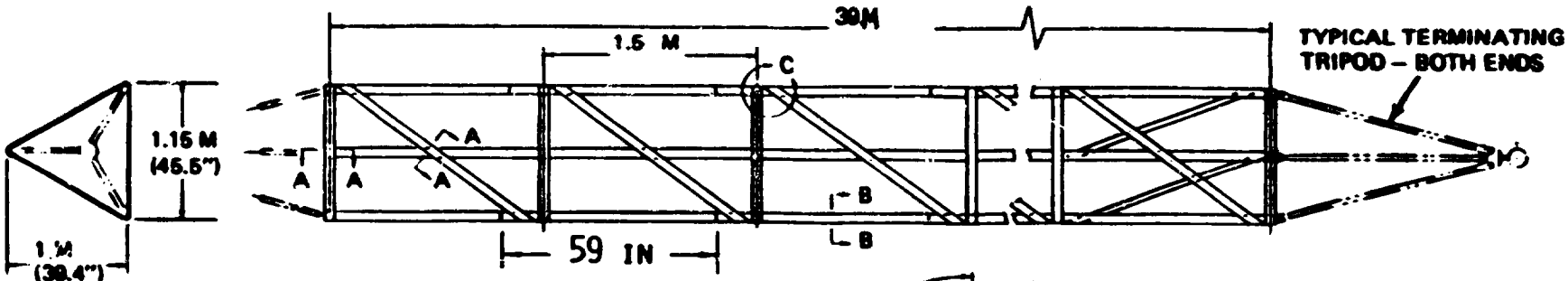
BEAM DESIGN CONFIGURATION

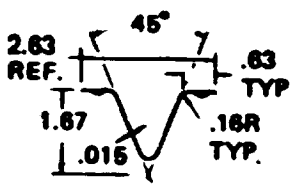
BEAM BUILDER STRUCTURAL ARRANGEMENT

BEAM BUILDER INSTALLATION IN ORBITER

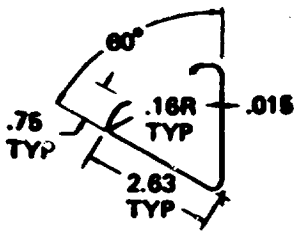
ONE METER BEAM DESIGN







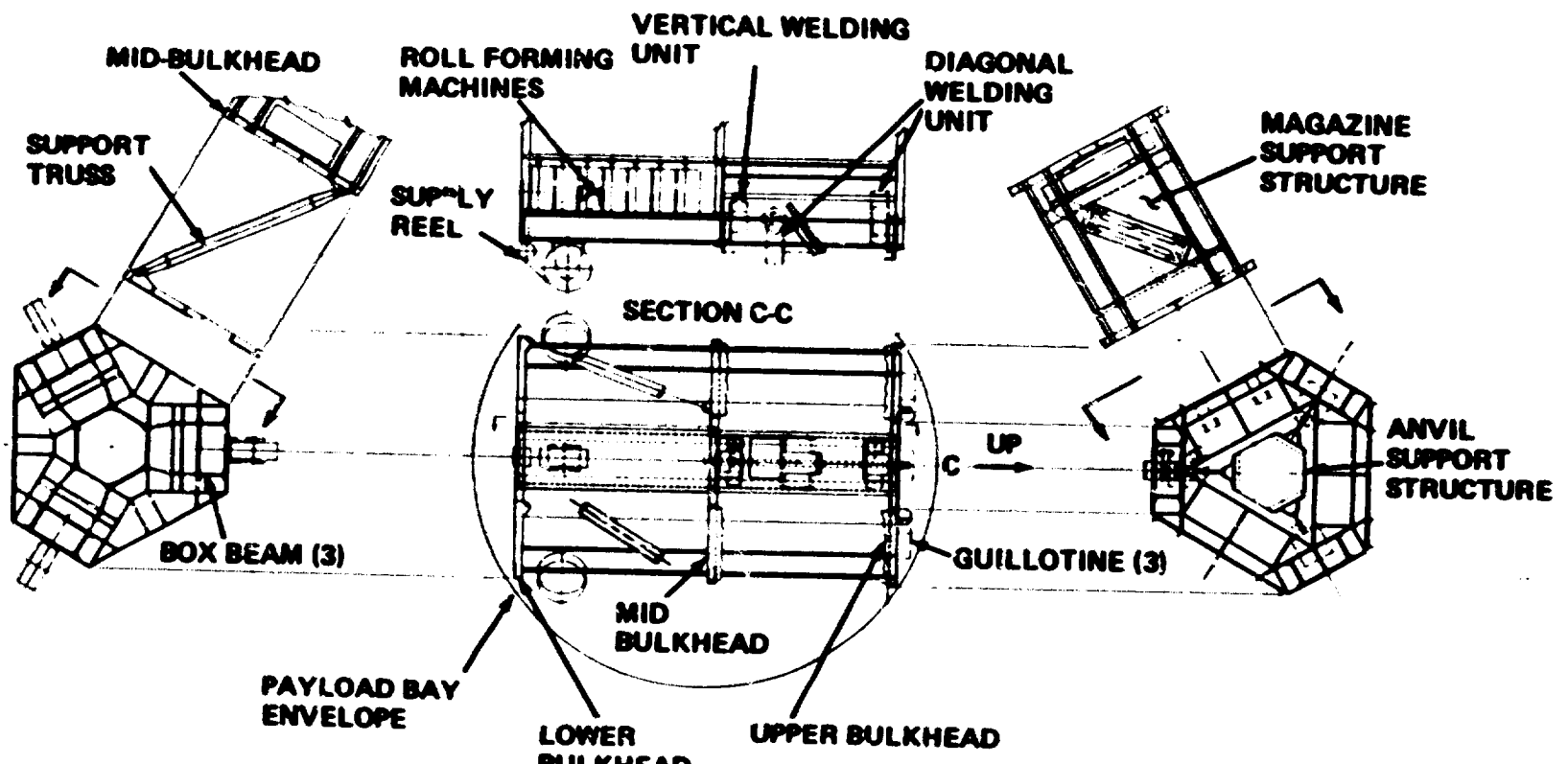
SECTION A-A



SECTION B-B

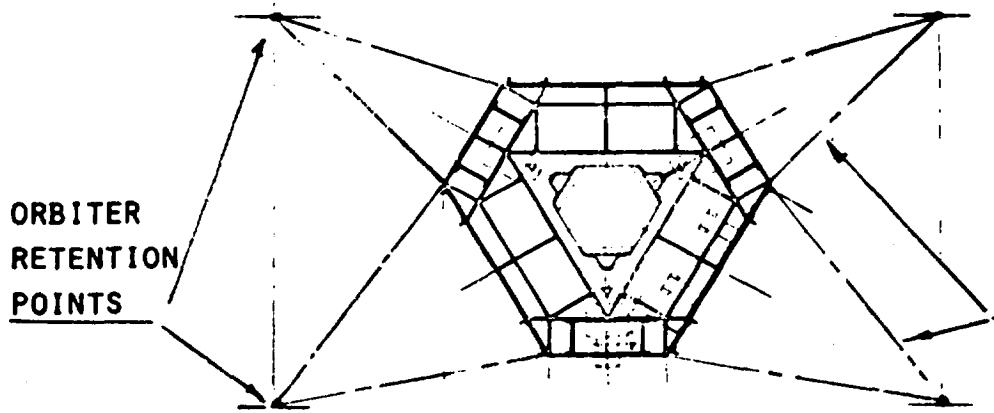
REF. DRAWING NO RDM-447-4021

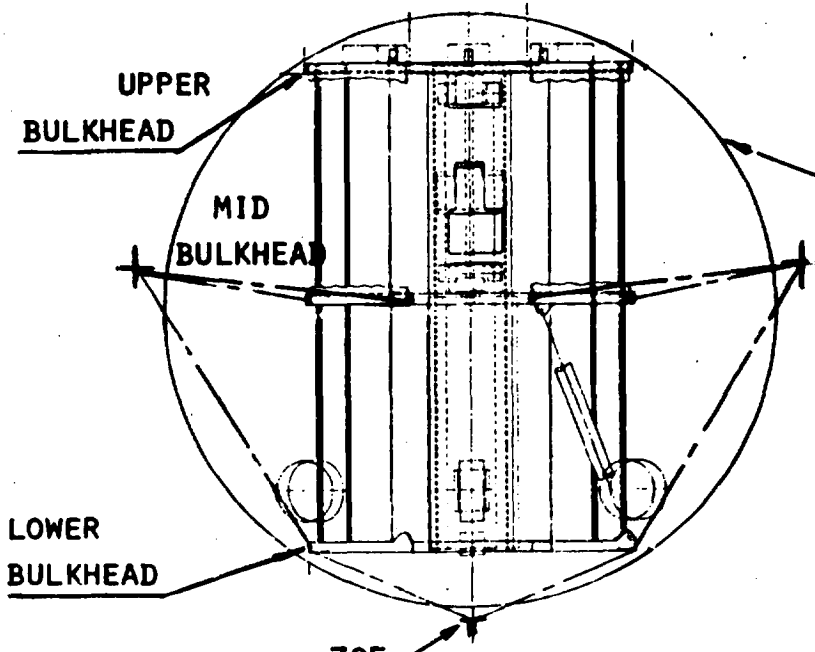
BEAM BUILDER STRUCTURAL ARRANGEMENT



VIEW LOOKING FWD

2105-110W





VIEW LOOKING FORWARD

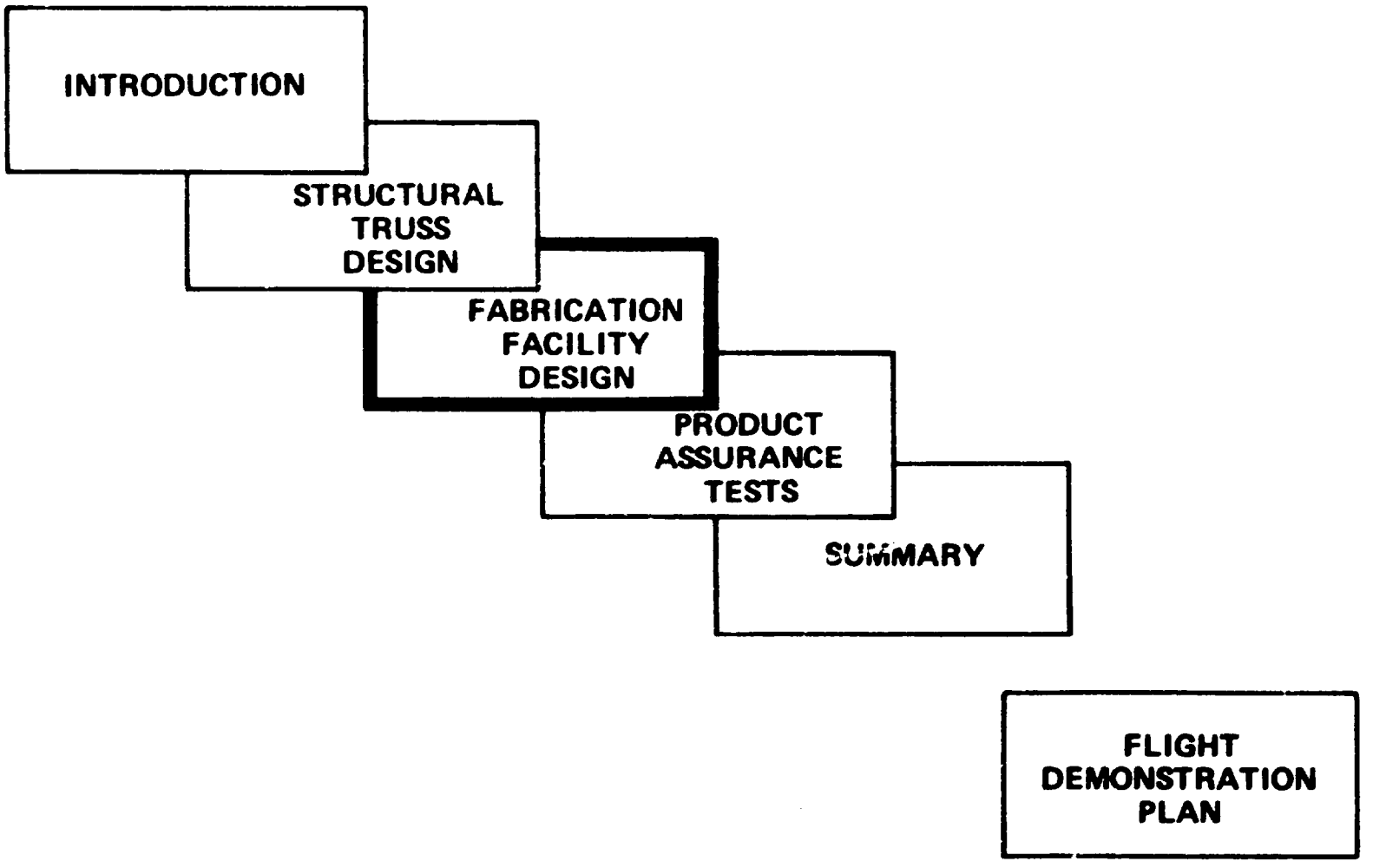
SPACE FABRICATION
FLIGHT CONFIGURATION

GRUMMAN

ORIGINAL PAGE IS
OF POOR QUALITY

CONCLUSIONS

- DESIGN LOADS AND TEMPERATURES EVALUATED FOR:
  - I FABRICATION IN ORBITER PAYLOAD BAY
  - II SSPS VEHICLE
- MATERIALS AND PROCESSES SELECTED MEET REQUIREMENTS
  - 2024-T3; 2219-T6; 6061-T6
  - THERMAL COATINGS
  - ROLL FORMING
  - SPOTWELDING
- BEAM DESIGN HAS BEEN DEFINED AND SATISFIES CRITICAL CONDITIONS
- FABRICATION ACCURACY REQUIREMENT FOR BEAM DEFINED FOR FABRICATION FACILITY
- STRUCTURAL TEST ON NOV 1976 ESTABLISHES CONFIDENCE IN BASIC DESIGN


INTRODUCTION
STRUCTURAL TRUSS DESIGN
FABRICATION FACILITY DESIGN
PRODUCT ASSURANCE TESTS
SUMMARY
FLIGHT DEMONSTRATION PLAN

2105-005W

GROUND DEMONSTRATION
MACHINE FABRICATION FACILITY

QUARTERLY REVIEW

AUGUST 26, 1977

2105-011W

DESIGN REQUIREMENTS

- LOW COST
- COMPLY WITH SHUTTLE PAYLOAD CONSTRAINTS
- MAXIMUM USE OF COMMERCIAL "OFF-THE-SHELF" HARDWARE
- MAXIMUM USE OF EXISTING "STATE-OF-THE-ART" EXPERTISE
- COMPATIBLE WITH FUTURE FLIGHT TEST NEEDS
- FULLY AUTOMATED FABRICATION OF TRUSS

WORKING MOCKUPS

- MACHINE CONFIGURATION
- MAGAZINE MECHANISM
- CLAMP & WELD ELECTRODE MECHANISM
- CAP CUTOFF

2105-054W

FACILITY DESIGN

AREAS OF DISCUSSION

- OVERALL CONFIGURATION
- ROLL-FORMING CAP MEMBER
- MAGAZINE/DISPENSER BRACE MEMBERS
- BRACE ATTACHMENT
- TRUSS CUTOFF AND INTERNAL SUPPORT
- CONTROLS
- SUMMARY

PRINCIPAL MACHINE PROCESSES

- ROLL-FORM CAP MEMBERS
- MAGAZINE STORE PREFAB BRACES
- RESISTANCE-WELD ATTACHMENT
- COMPUTER CONTROL CAP ALIGNMENT

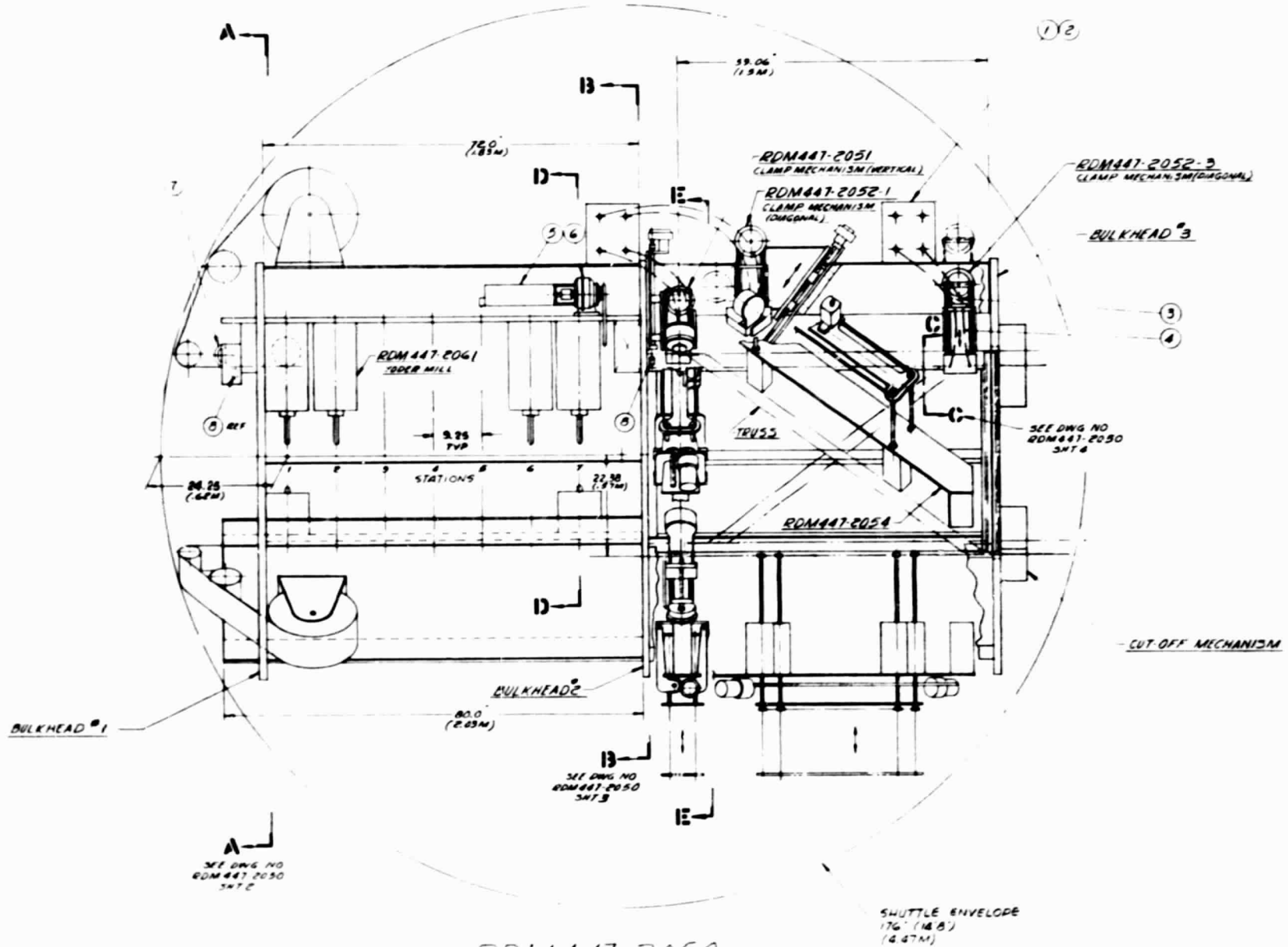
PRINCIPAL SUBSYSTEMS

- ROLL FORMING
- MAGAZINE/CLAMP MECHANISM
- ATTACHMENT
- CUTOFF & SUPPORT
- CONTROLS

FACILITY DESIGN

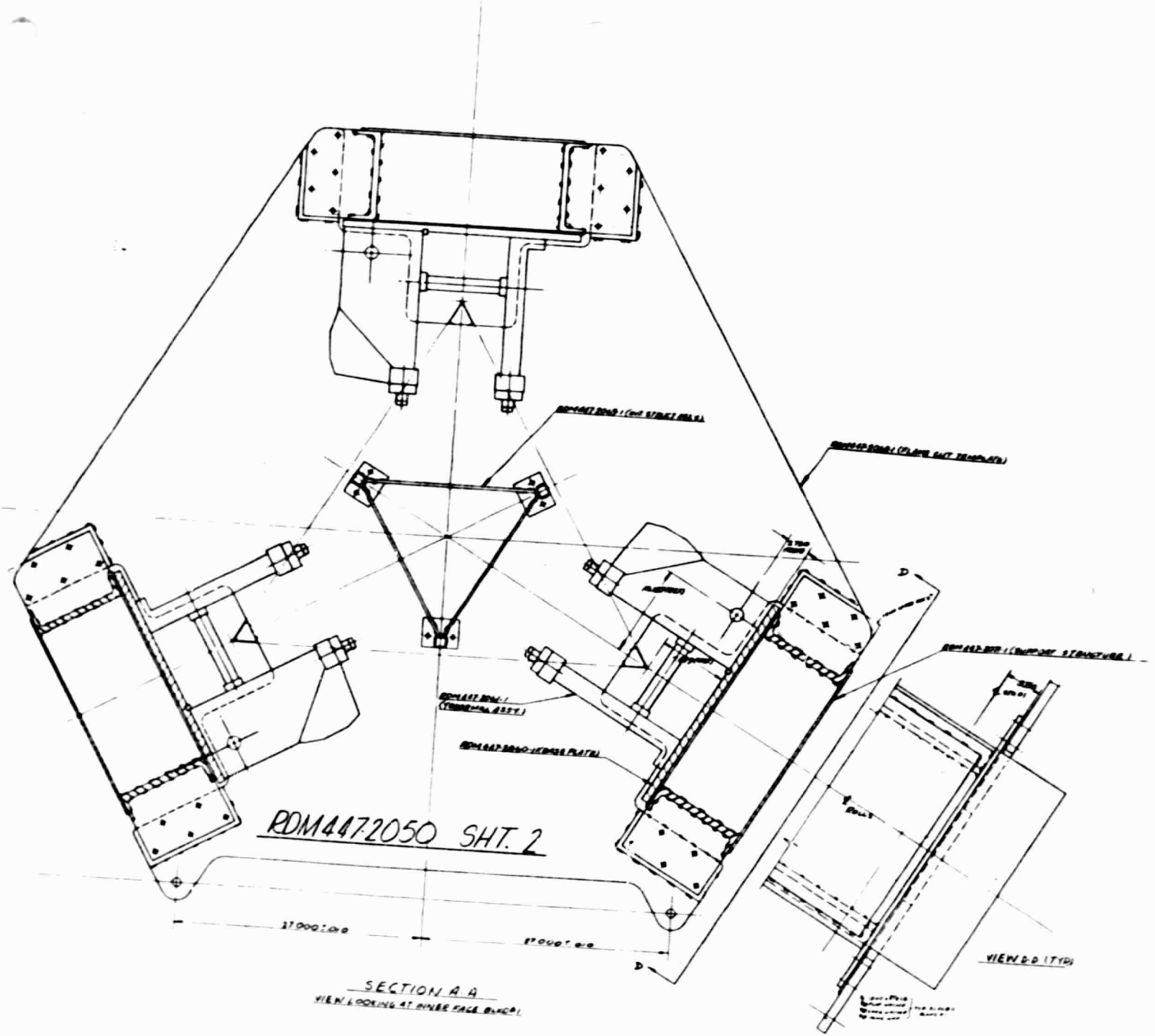
AREAS OF DISCUSSION

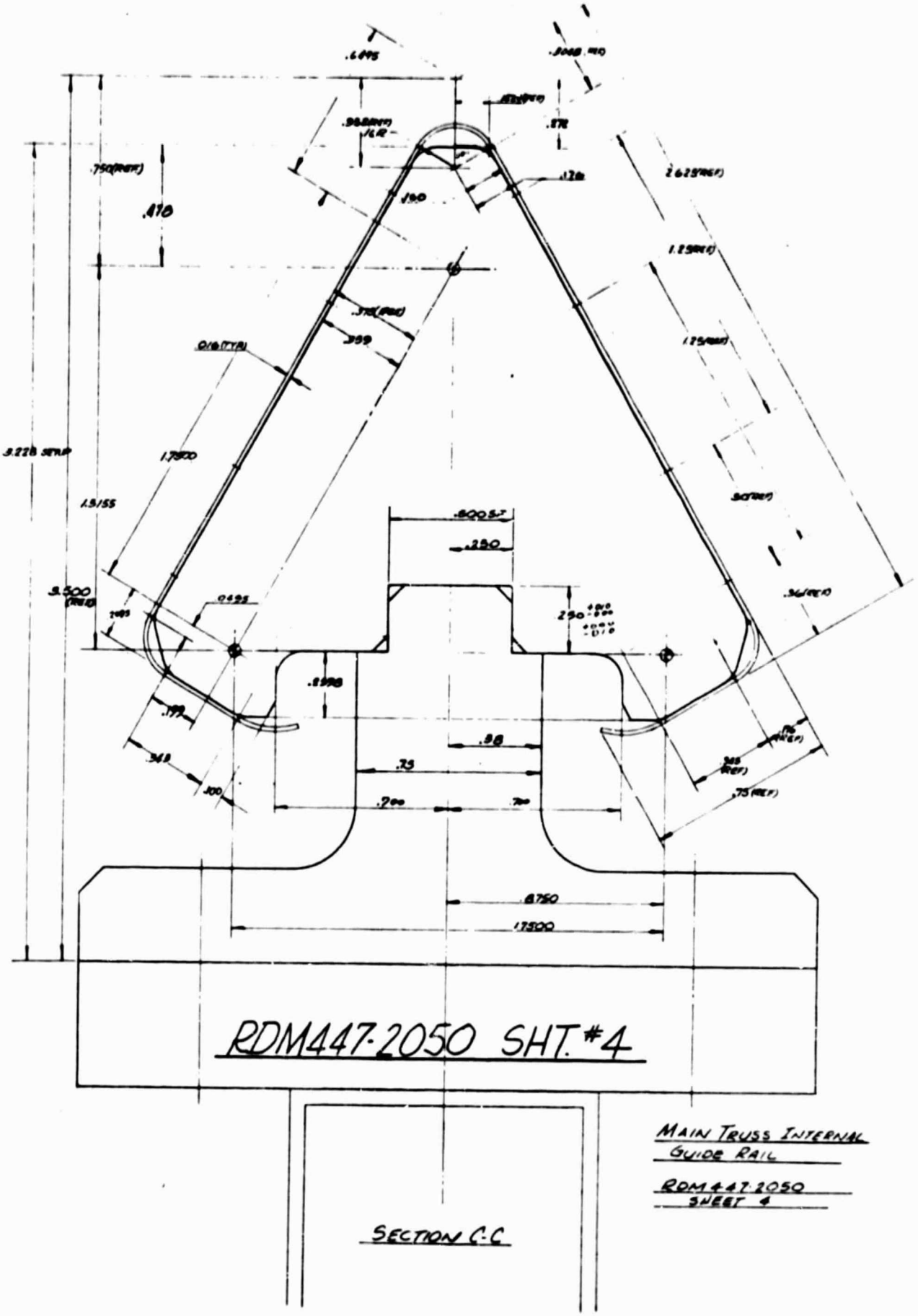
- **OVERALL CONFIGURATION**
- ROLL-FORMING CAP MEMBER
- MAGAZINE/DISPENSER BRACE MEMBERS
- BRACE ATTACHMENT
- TRUSS CUTOFF AND INTERNAL SUPPORT
- CONTROLS
- SUMMARY



RDM447-2050 B

SHT 1

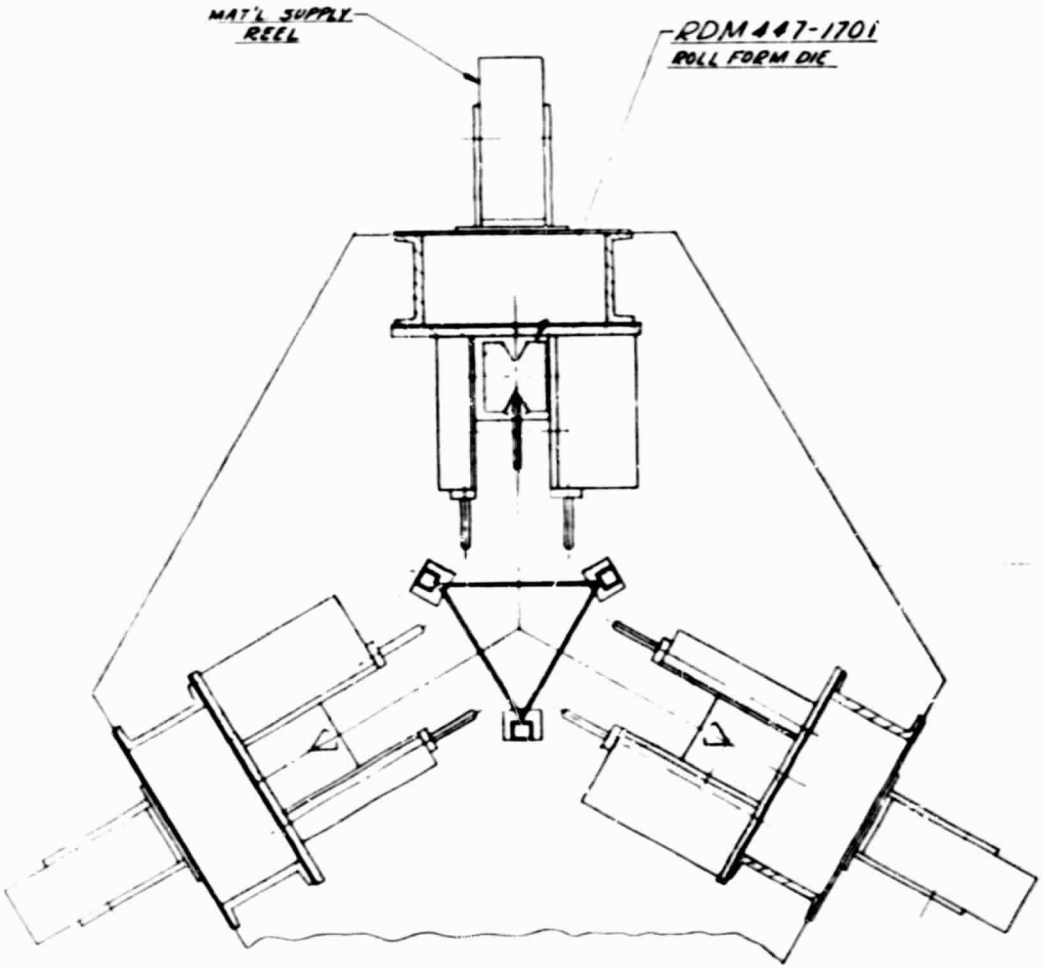

RDM4472050 SHT. 2
SECTION A A
VIEW LOOKING AT INNER FACE (LHS)
VIEW D-D (TYP)



MAIN TRUSS INTERNAL GUIDE RAIL

RDM447-2050 SHEET 4

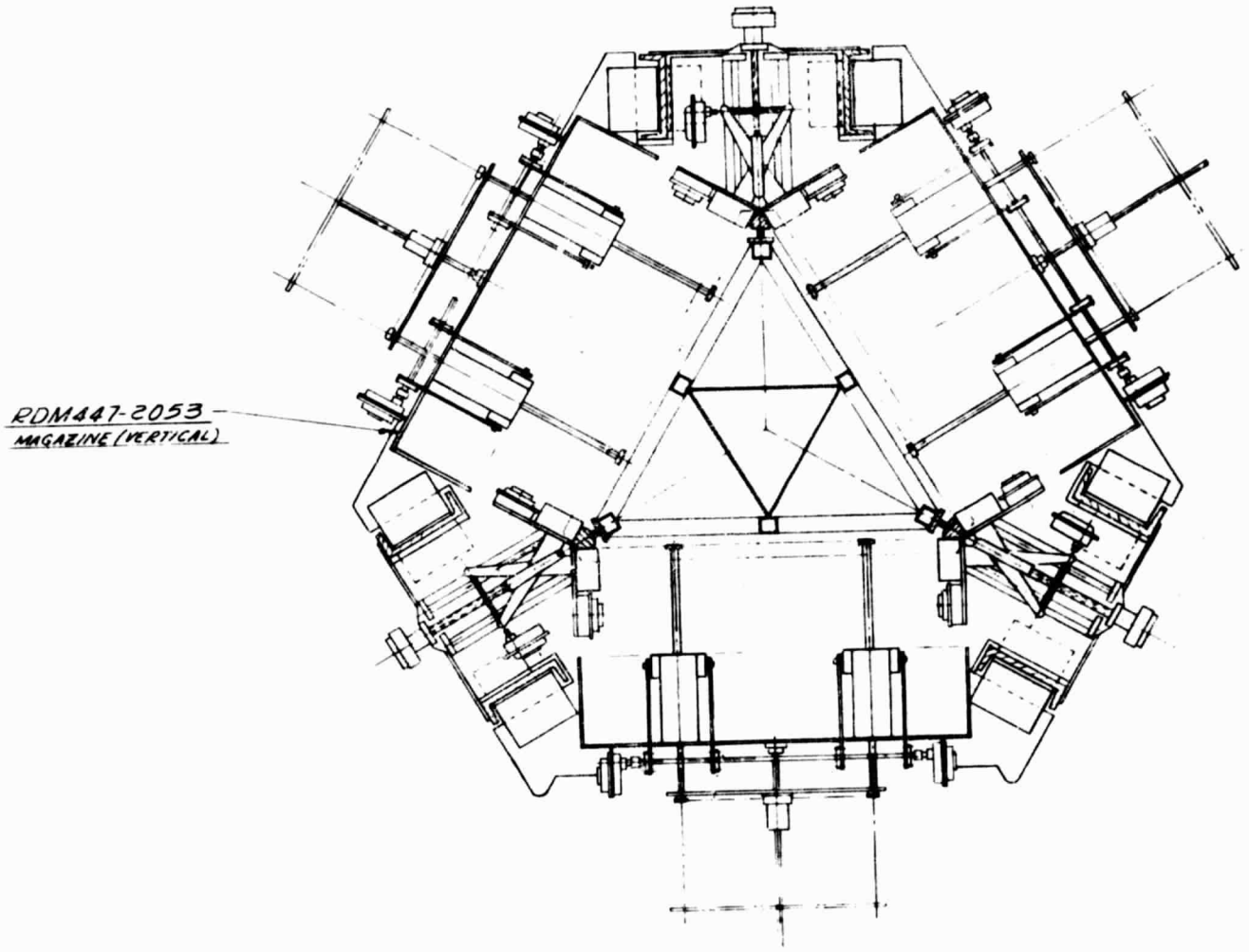
SECTION C-C



SECTION D-D

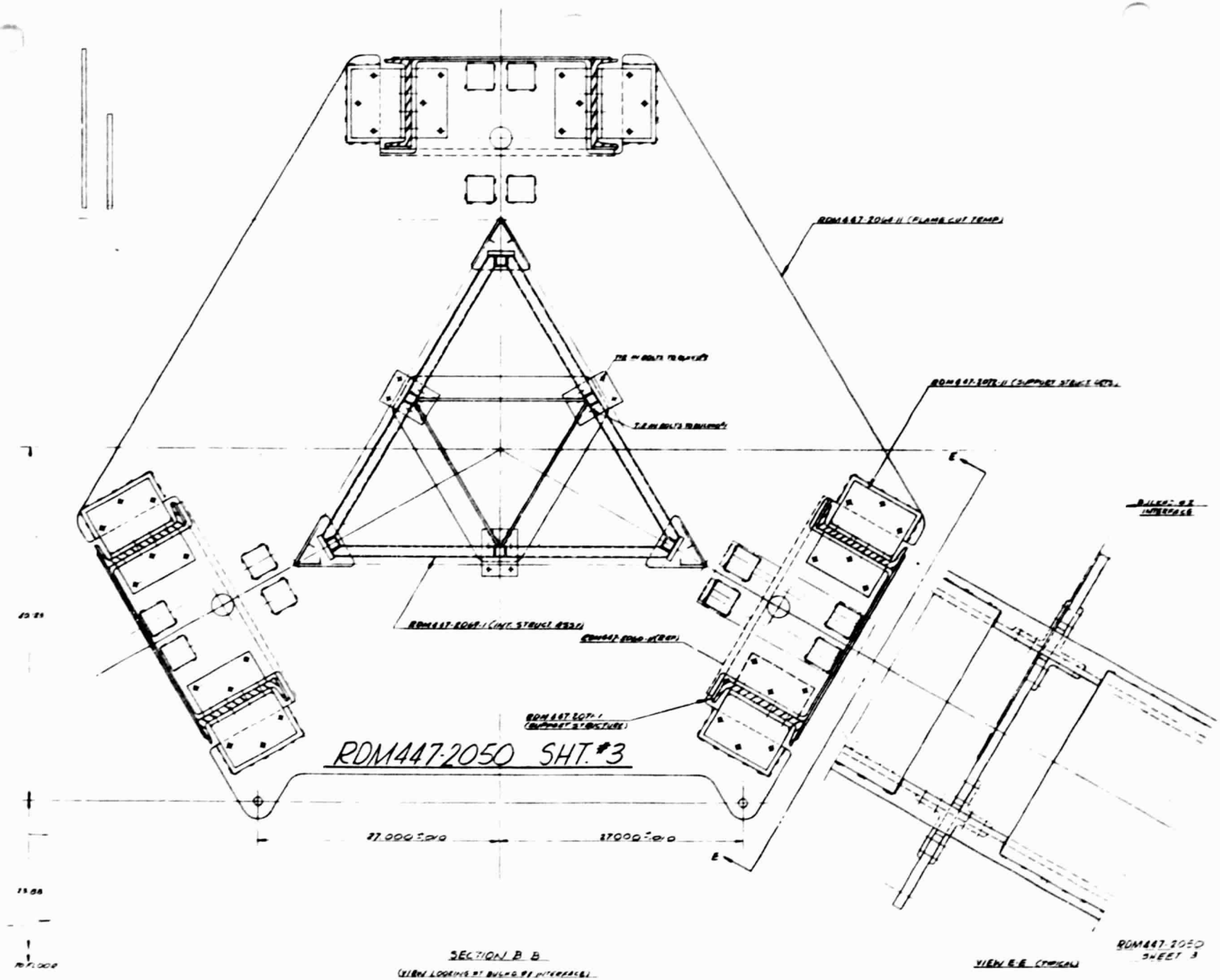
RDM 447-2050 A

SHT 1

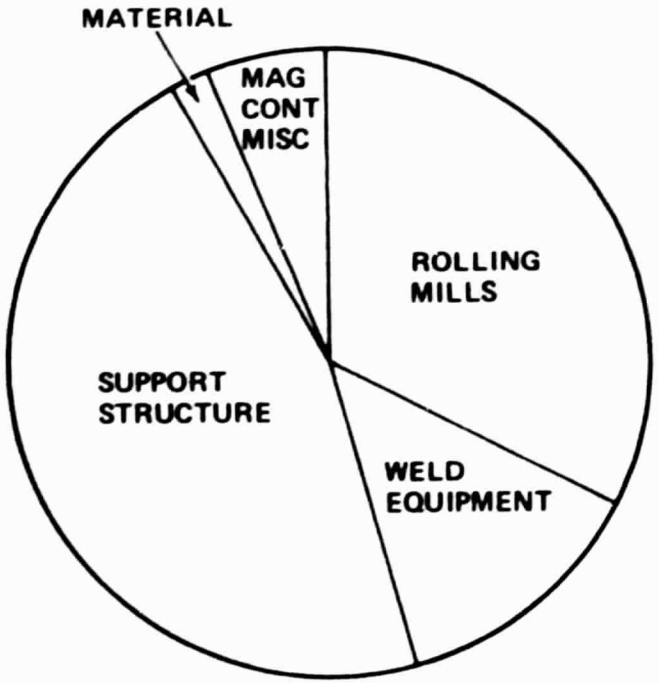


SECTION E-E

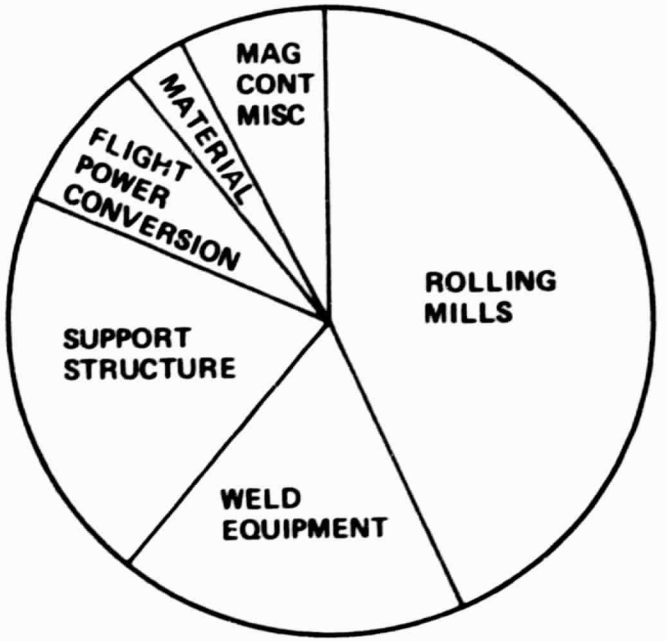
RDM447-2050c
SHT 1



PROJECTED WEIGHT DISTRIBUTION



GROUND UNIT
9070 KG
(20,000 LBS)



FLIGHT TEST
7256 KG
(16,000 LBS)

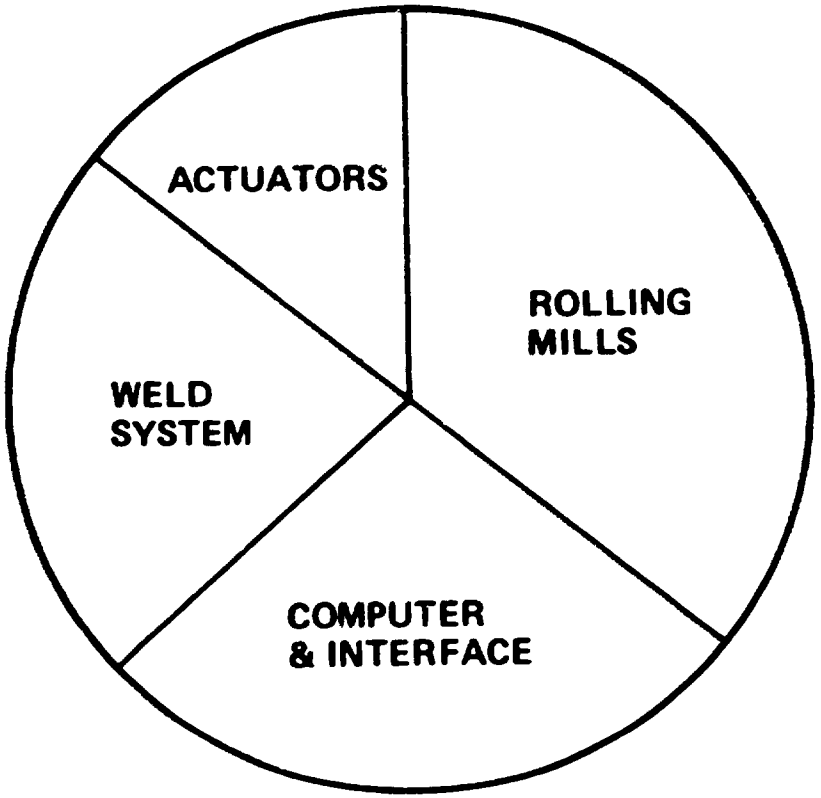
GRUMMAN

2105-037W

GROUND DEMONSTRATION MACHINE PROJECTED WEIGHT DISTRIBUTION

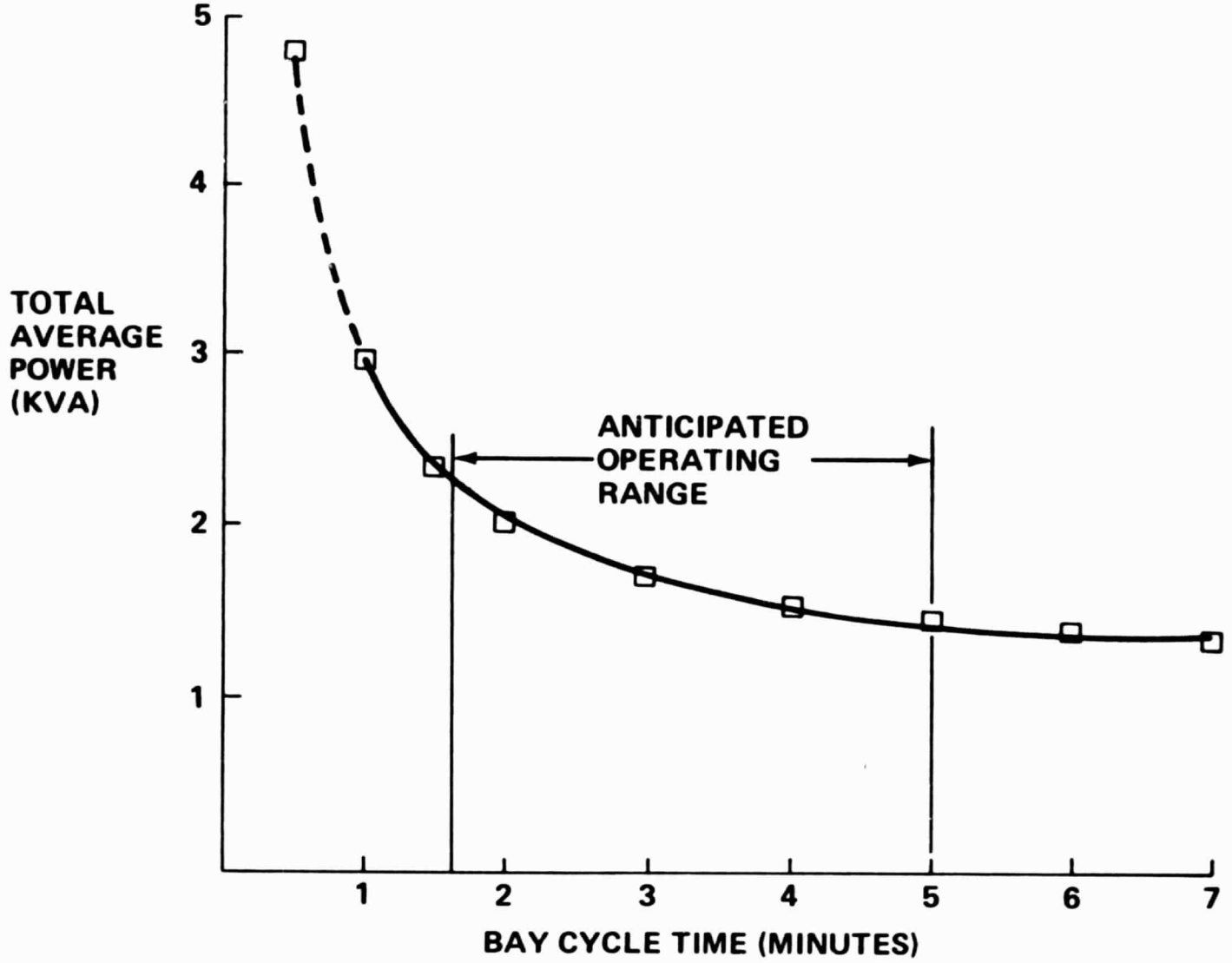
• ROLLING MILL	2876 KG (6255 LBS)
• BRACE DISPENSERS	163 KG (360 LBS)
• WELDING SYSTEM	1170 KG (2580 LBS)
• CONTROL SYSTEM	318 KG (702 LBS)
• MATERIALS	210 KG (462 LBS)
• SUPPORT STRUCTURE	4081 KG (9000 LBS)

PROJECTED AVG POWER DISTRIBUTION



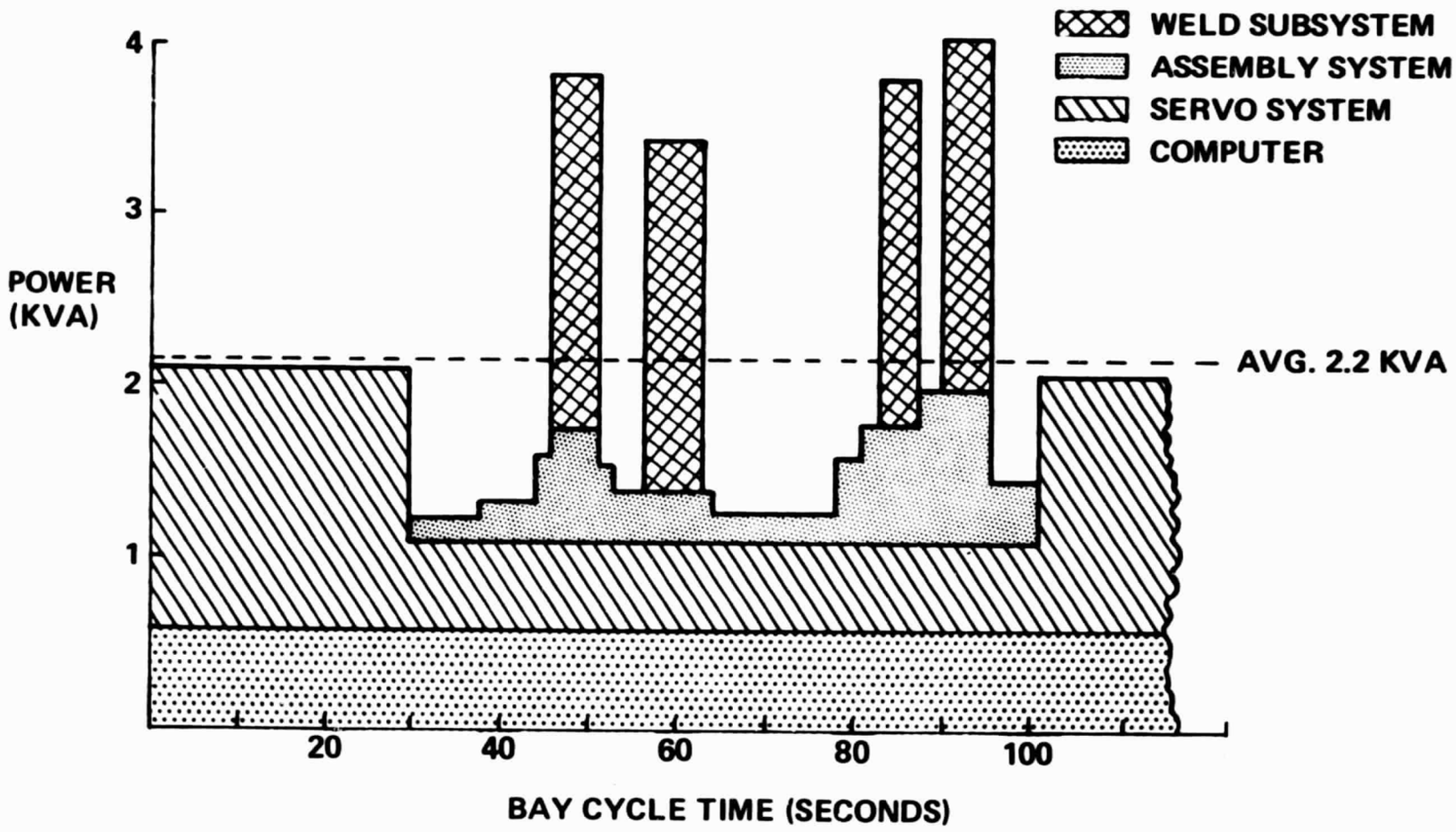
AVG. 2.2 KVA

AVERAGE POWER VS BAY FABRICATION TIME

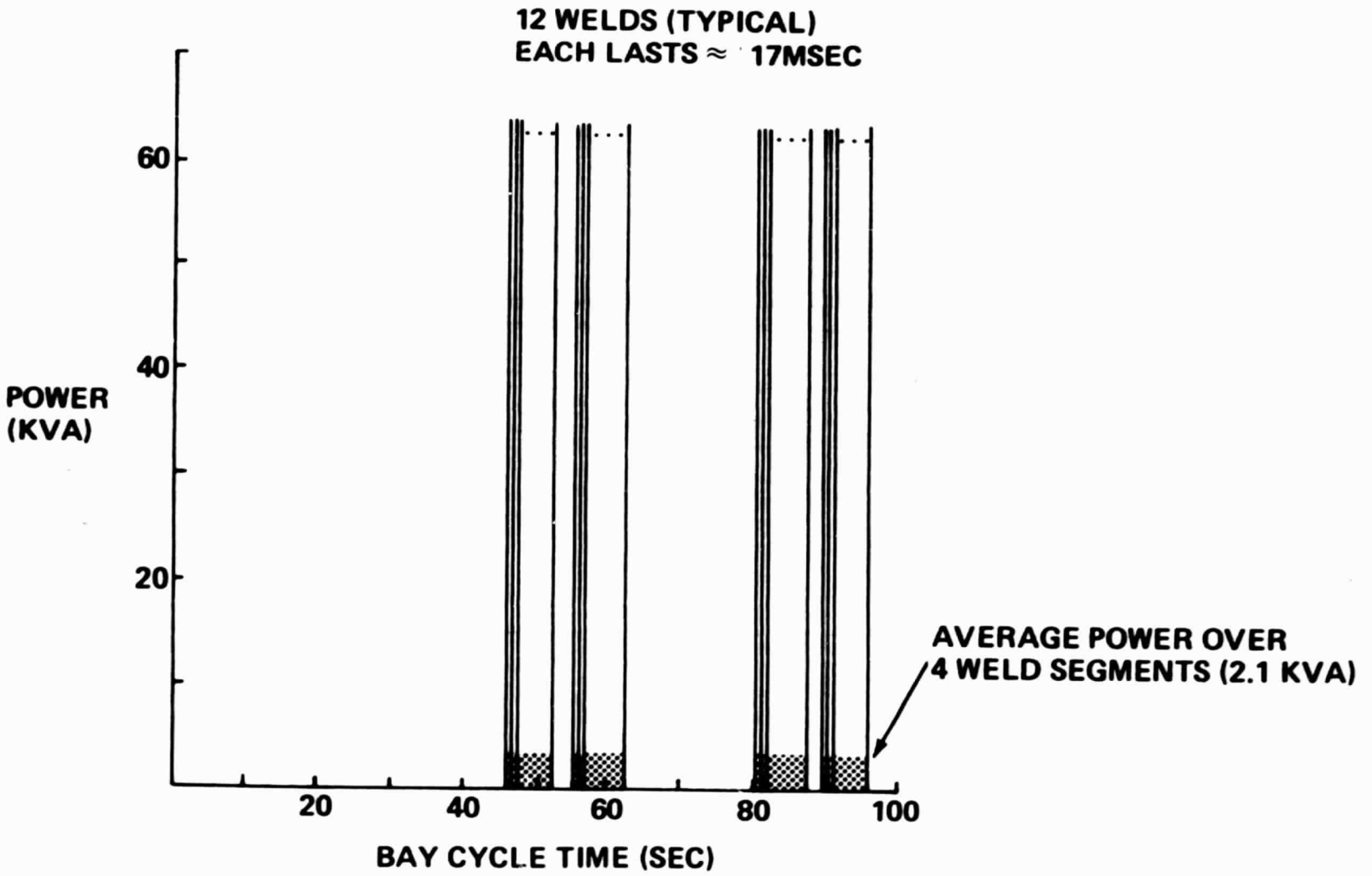


2105-076W

TOTAL POWER REQUIREMENTS FOR GROUND DEMONSTRATION SYSTEM



WELD POWER REQUIREMENTS



GRUMMAN

FACILITY DESIGN

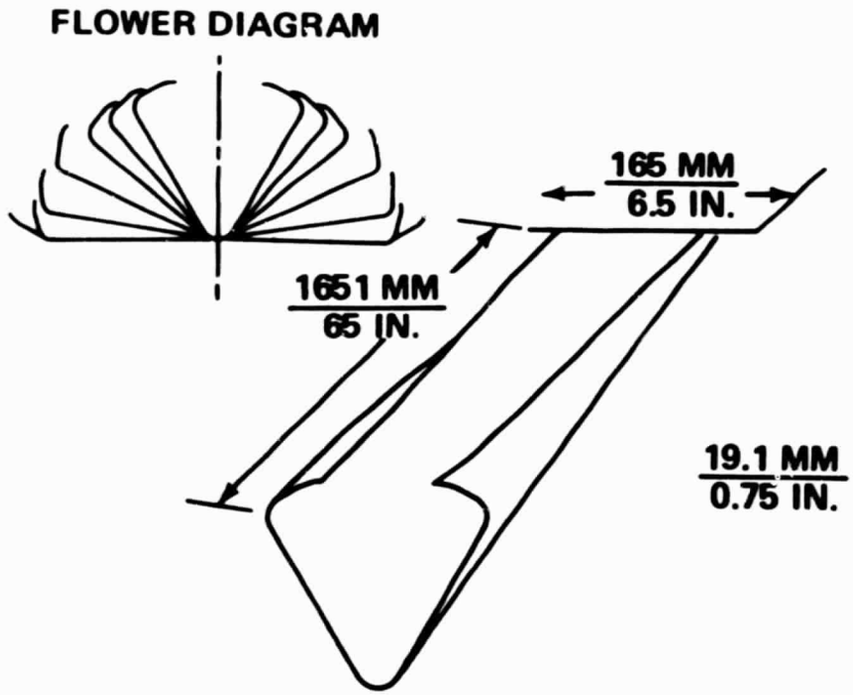
AREAS OF DISCUSSION

- OVERALL CONFIGURATION
- **ROLL-FORMING CAP MEMBER**
- MAGAZINE/DISPENSER BRACE MEMBERS
- BRACE ATTACHMENT
- TRUSS CUTOFF AND INTERNAL SUPPORT
- CONTROLS
- SUMMARY

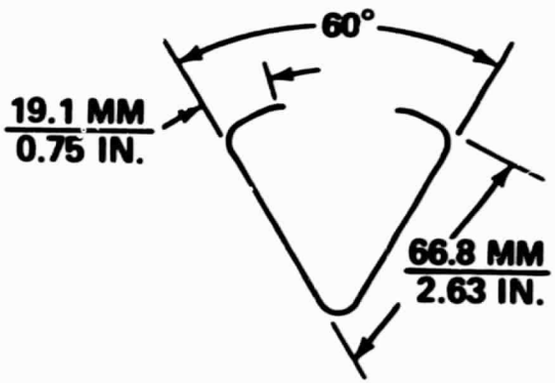
ROLL-FORM SUBSYSTEM

- FORM ROLLING MILL
- TOOLING
- SUPPORT STRUCTURE
- DRIVE SYSTEM

ROLL-FORMING CAP MEMBER



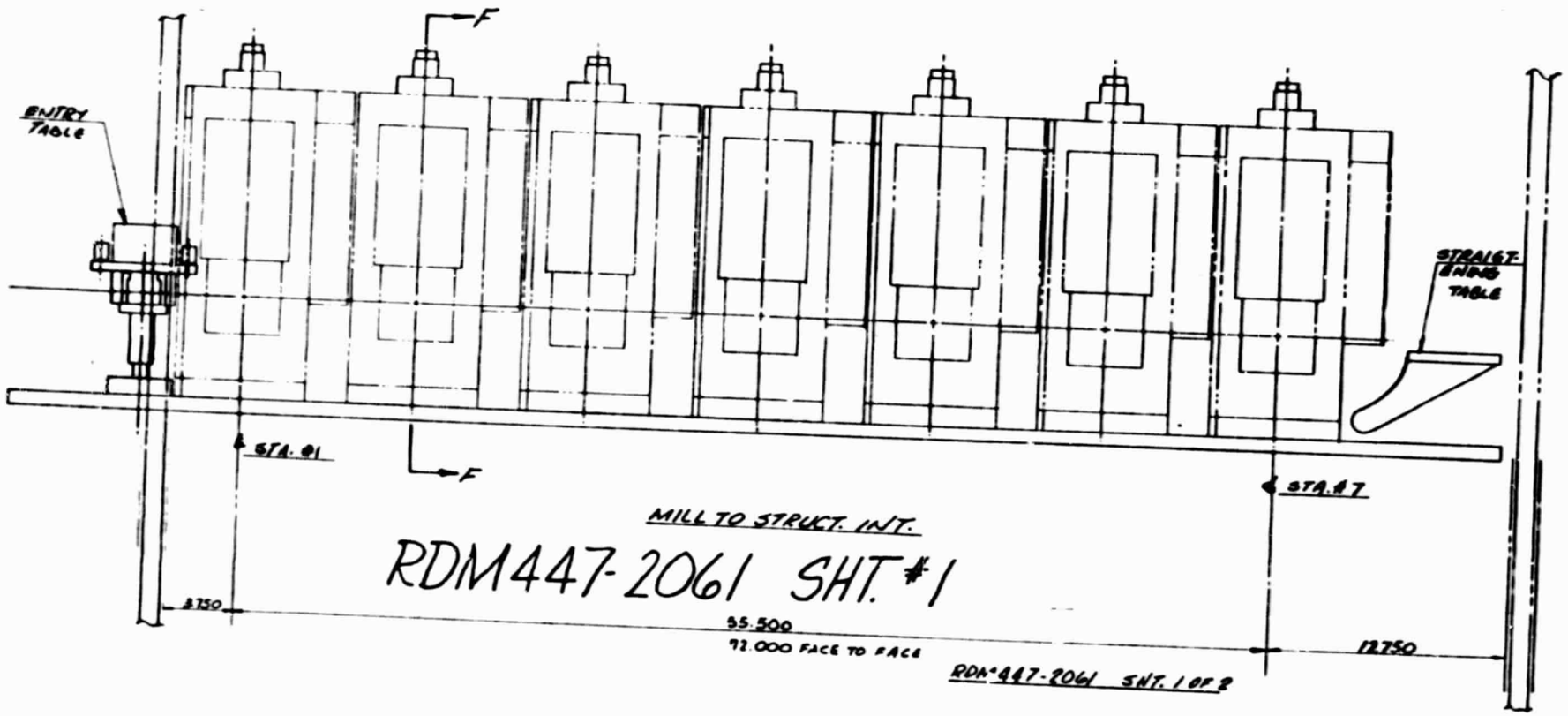
PROGRESSIVE FORMATION OF CAP

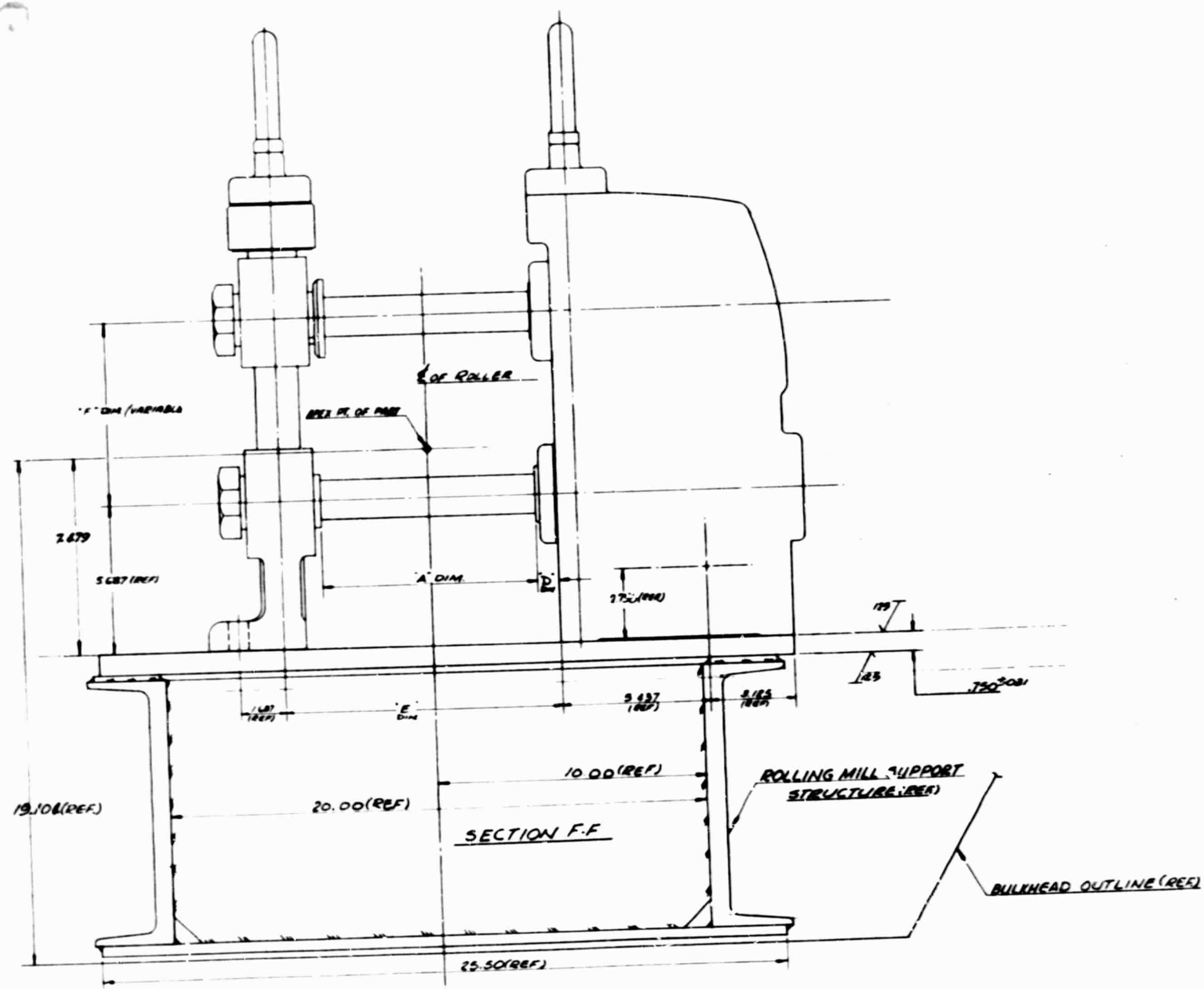


CROSS-SECTION

DEVELOPMENT TEST SUMMARY

TASK	RESULTS	ACTION
ESTABLISH 2219-T62, 2024-T3 SPRING BACK	2219-T62 (10 DEG) 2024-T3 (2 DEG)	PRELIMINARY ROLL DESIGN
REDUCE ROLL STATIONS	STATION REQMTS 8 → 7	ESTABLISH 65-IN LENGTH
PRELIMINARY CONFIGURATION EVALUATION	• RIPPLED FLANGE • LONGITUDINAL BOW	MODIFY ENTRY AND TRANSITION ROLLS
CONFIGURATION REFINEMENT	• IMPROVED FLANGE • ELIMINATE BOW	REDESIGN TRANSITION ROLLS
FLANGE EVALUATION	• MINIMAL WAVE	• ADD CROWN TO FLANGE • PROCEED WITH FINAL DESIGN


F
ENTRY TABLE
STRAIGT. ENDS TABLE
STA. 01
STA. 47
F
MILL TO STRUCT. INT.
RDM447-2061 SHT. #1
3750
95.500
92.000 FACE TO FACE
12750
RDM*447-2061 SHT. 1 OF 2

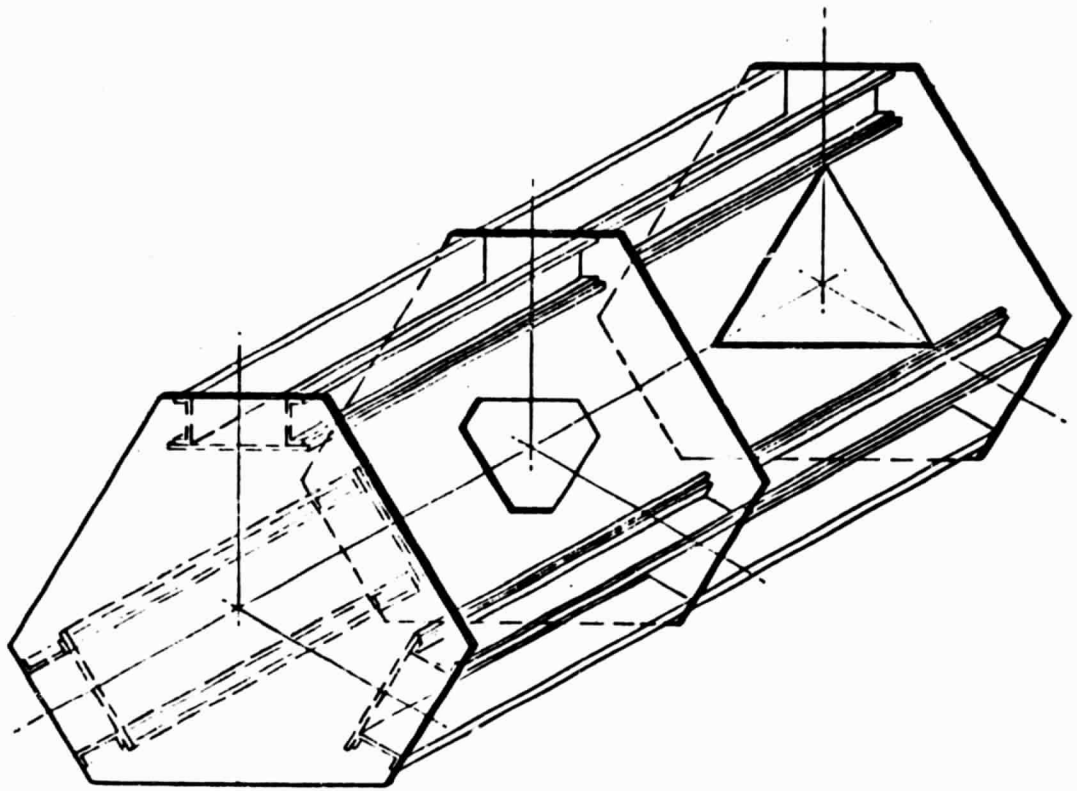


℄ OF ROLLER
"A" DIM.
"E" DIM
10.00(REF)
20.00(REF)
19.108(REF)
25.50(REF)
ROLLING MILL SUPPORT
STRUCTURE (REF)
BULKHEAD OUTLINE (REF)

SECTION F-F

EXTERNAL SUPPORT STRUCTURE

- MATERIAL – HOT ROLLED STEEL
- ARC WELD AND BOLTED CONSTRUCTION
- DWG. NO. RDM 447-2070



GRUMMAN

2105-108W

ROLLING MILL EQUIPMENT WEIGHT DISTRIBUTION

• ROLL HOUSING	857 KG (1890 LBS)
• TOOLING	1048 KG (2310 LBS)
• DRIVE	129 KG (285 LBS)
• GUIDE & STRAIGHTENER	381 KG (840 LBS)
• OTHER	422 KG (930 LBS)
TOTAL	2836 KG (6255 LBS)

SUMMARY – ROLL-FORMING SUBSYSTEM

- PRODUCED A ROLL-FORMED CAP MEMBER
- YODER ROLLING MILLS ON ORDER
- FINAL TOOL DESIGN UNDERWAY AT YODER
- EQUIPMENT CONFIGURATION CONSISTENT WITH SHUTTLE REQM'TS
- SUPPORT STRUCTURE DEFINED

UNDETERMINED

- SUPPLY REEL FINAL CONFIGURATION

FACILITY DESIGN

AREAS OF DISCUSSION

- OVERALL CONFIGURATION
- ROLL-FORMING CAP MEMBER
- **MAGAZINE/DISPENSER BRACE MEMBERS**
- BRACE ATTACHMENT
- TRUSS CUTOFF AND INTERNAL SUPPORT
- CONTROLS
- SUMMARY

GRUMMAN

2105-136W

MAGAZINE & CLAMP MECHANISMS

- BRACE STORAGE & DISPENSER
- ATTACHMENT CLAMP MECHANISM

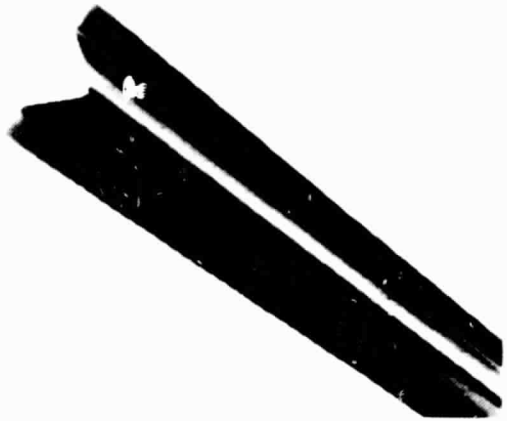
GRUMMAN

BRACE MAGAZINE/DISPENSER PRINCIPAL COMPONENTS

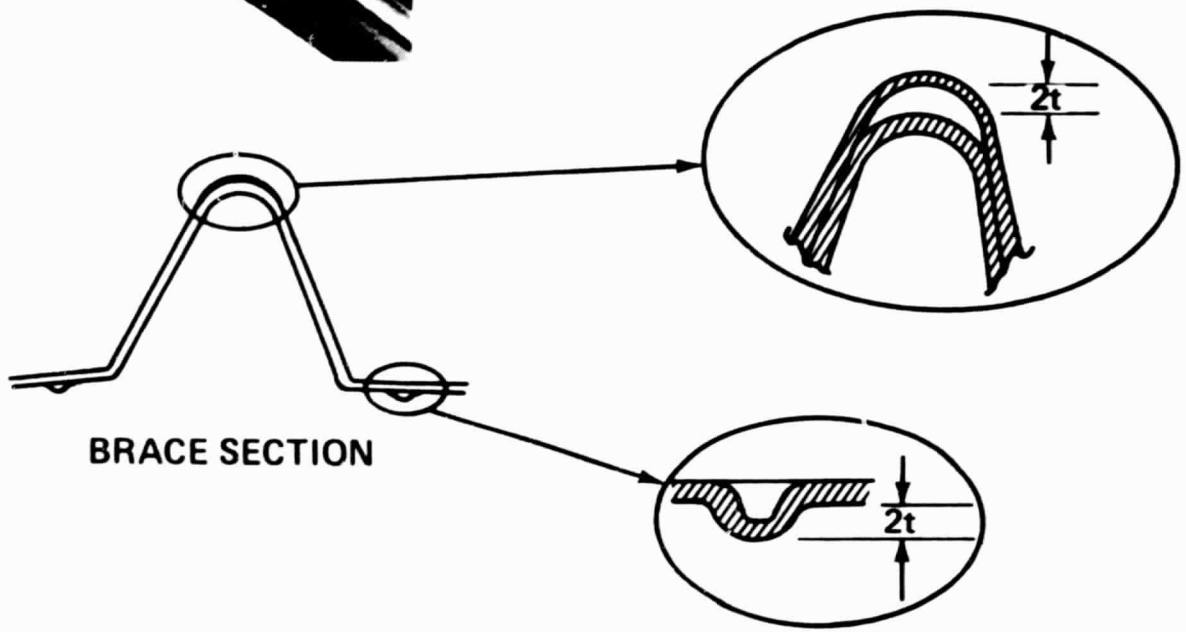
- MAGAZINE STOP ACTUATORS
- BRACE HANDLER ACTUATOR
- VERTICAL MAGAZINE FRAME
- DIAGONAL MAGAZINE FRAME

2105-043W

BRACE FABRICATION



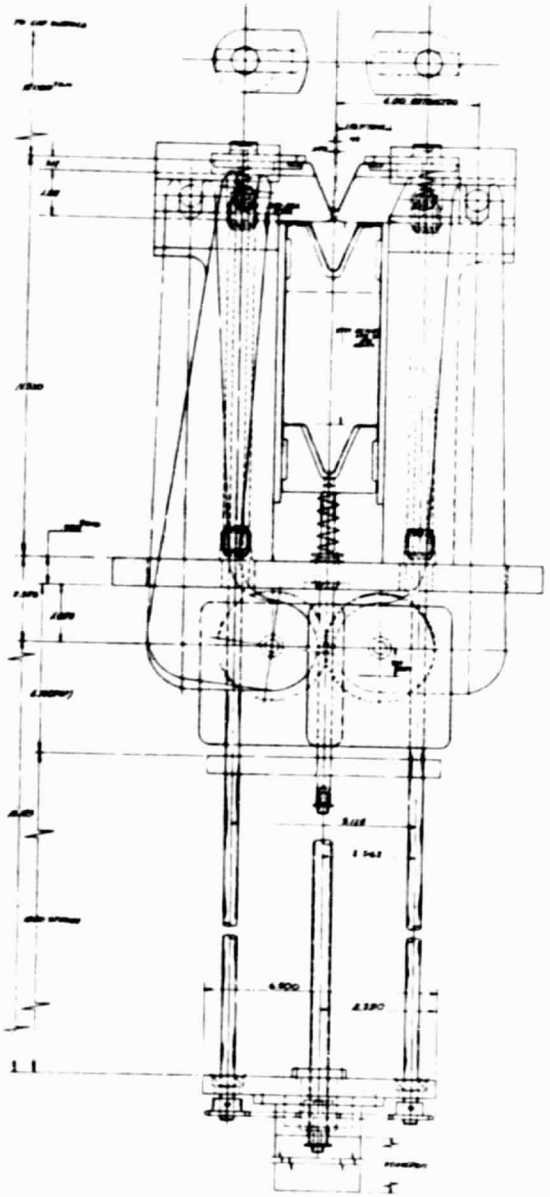
- BLANK MATERIAL
- FORM SECTION
- FORM DIMPLES
- ANODIZE (FLIGHT ARTICLE)

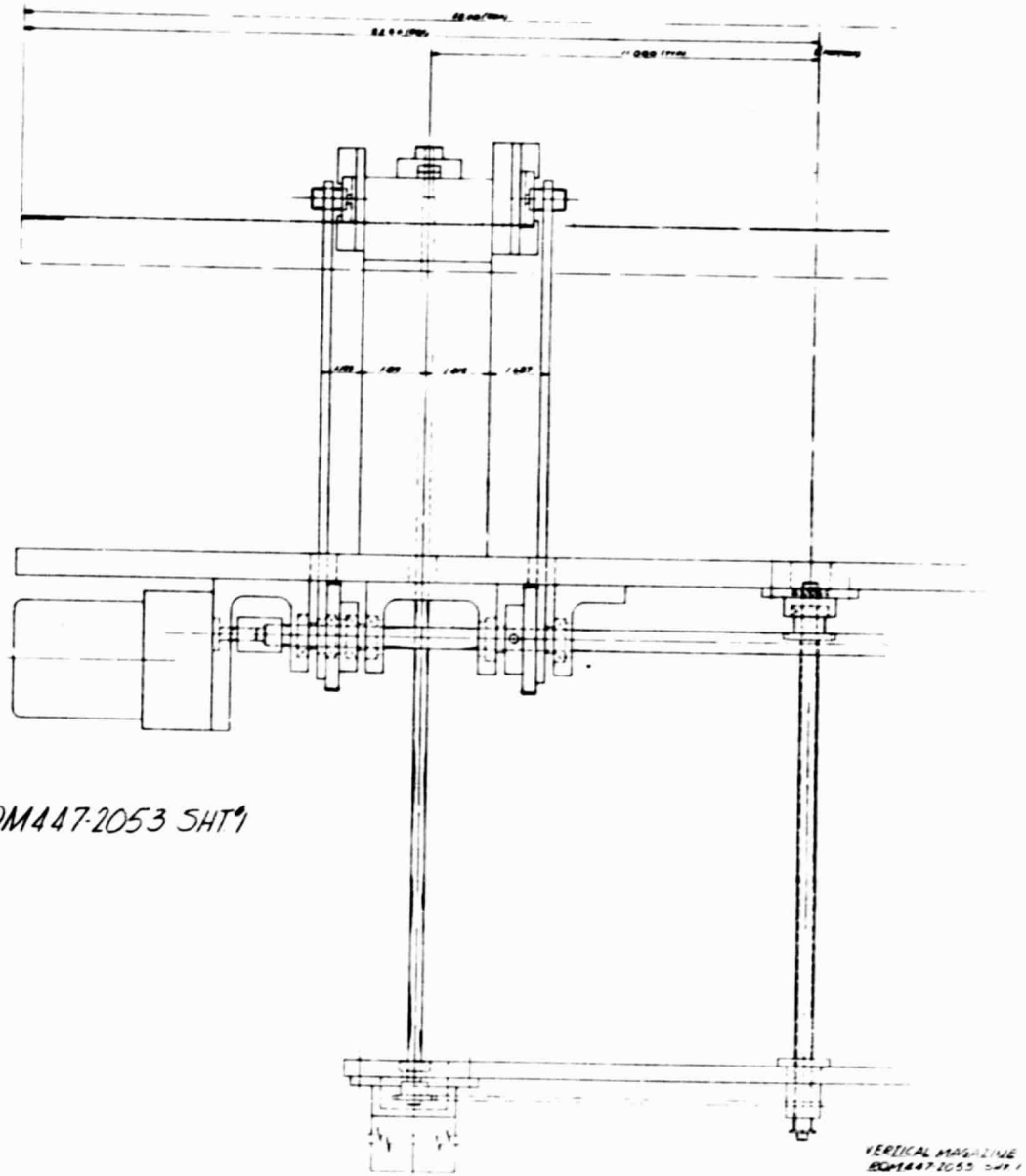


BRACE SECTION

GRUMMAN

2105-71W

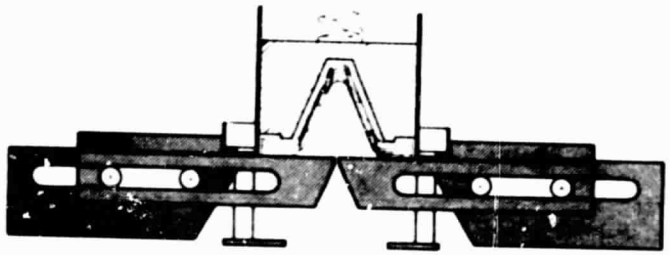




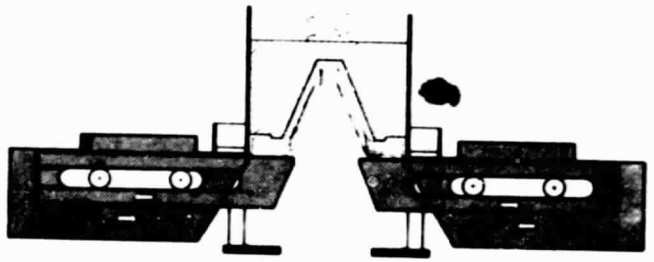
RDM447-2053 SHT 1

VERTICAL MAGNET
RDM447-2053 SHT 1

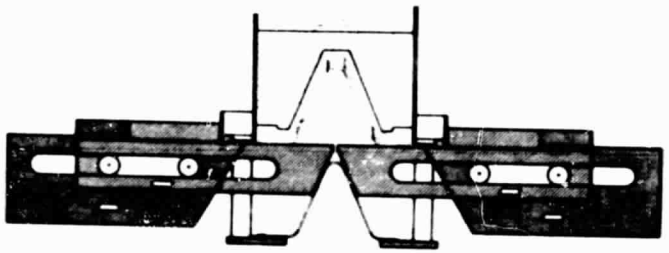
STEPS IN BRACE HANDLING



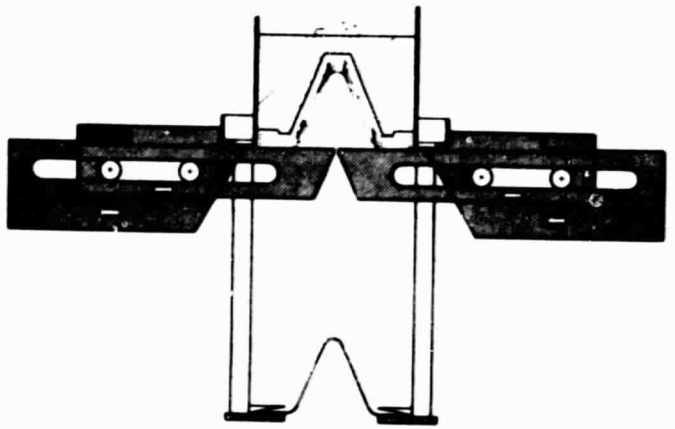
1. REST POSITION-BRACES IN MAGAZINE



2. TSS SEPARATES BRACE 1 FROM BRACE 2



3. BRACE DISPENSED FROM MAGAZINE



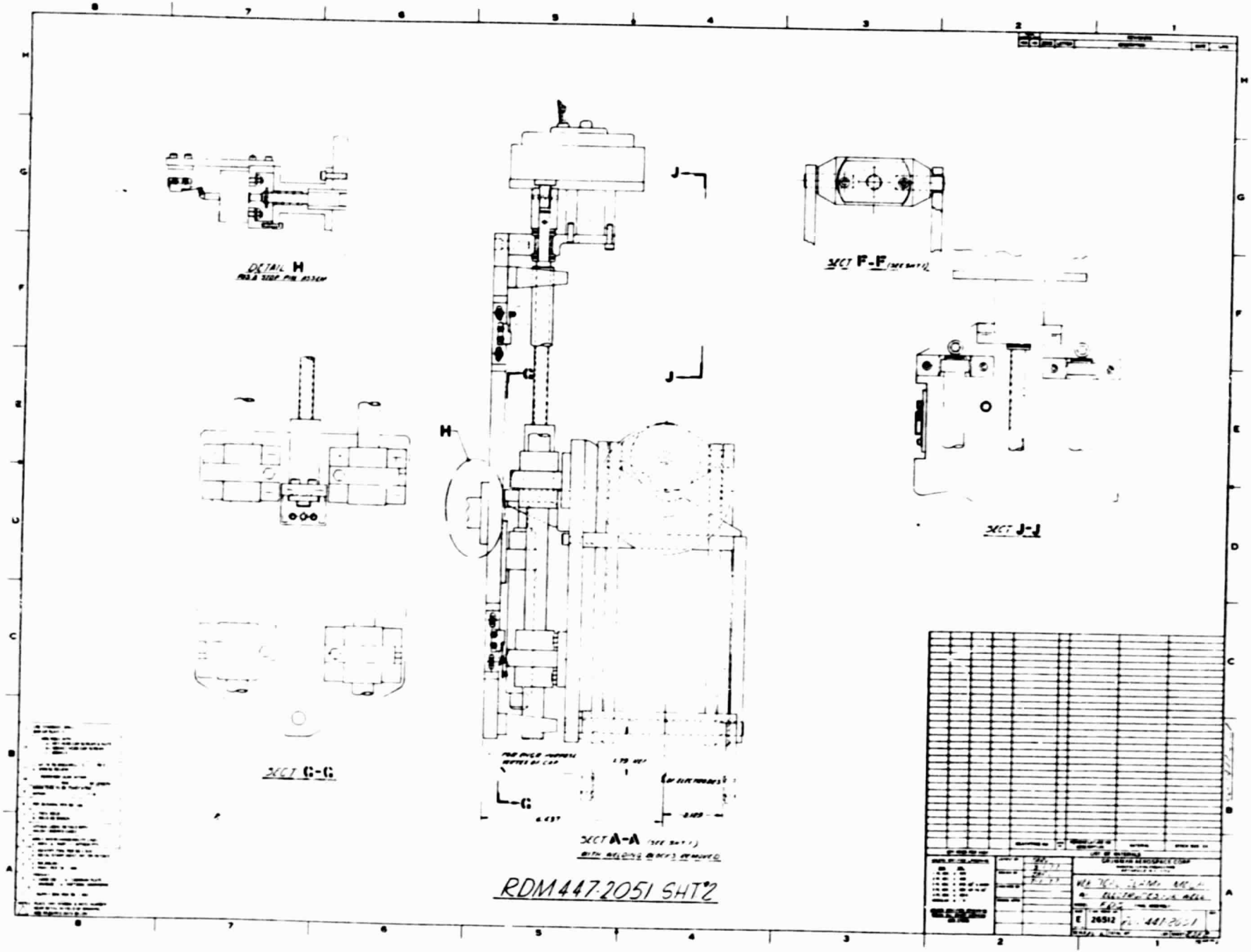
4. BRACE MOVED TO CAP

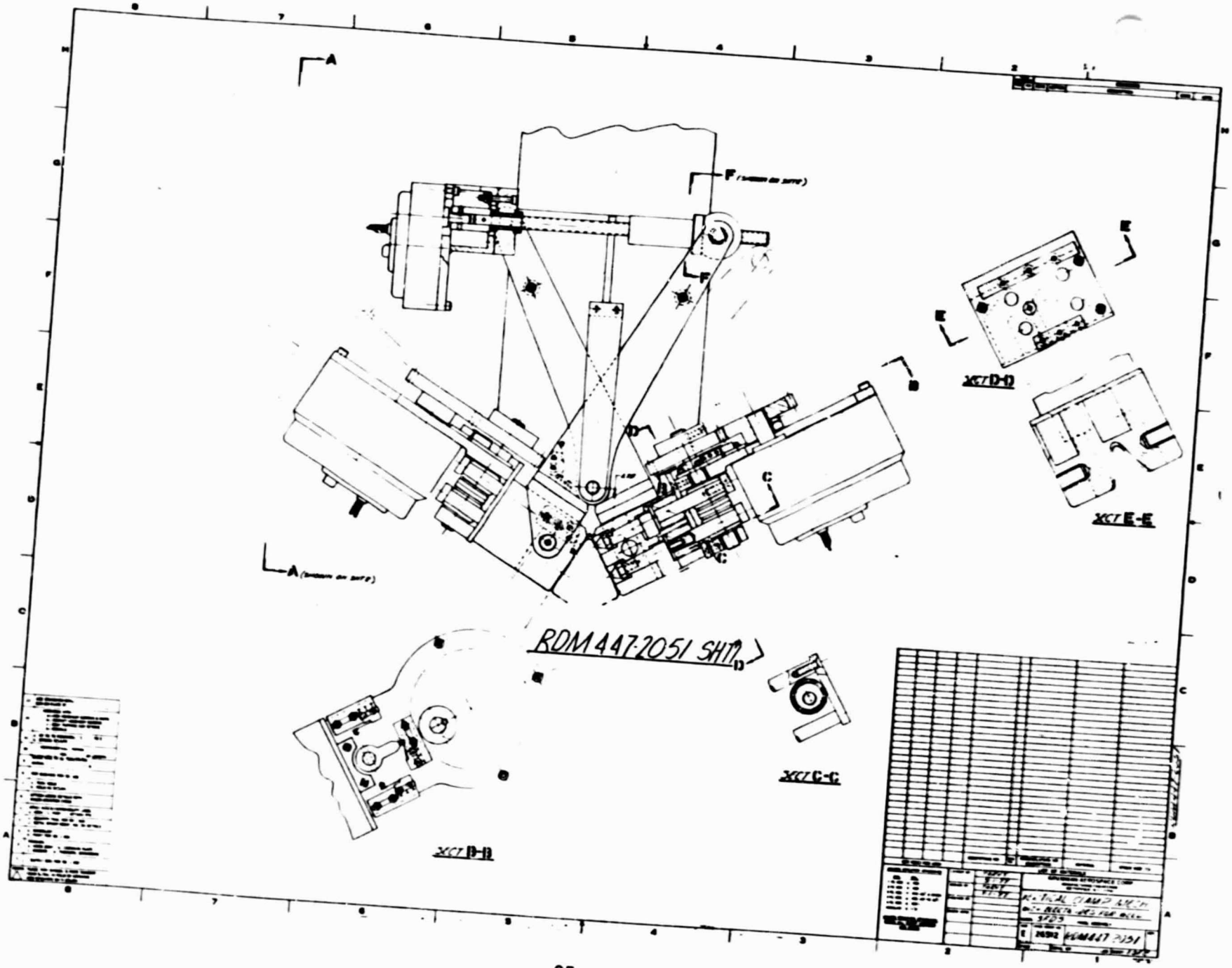
GRUMMAN

2105-077W

CLAMP ATTACHMENT MECHANISM

- HOUSING FOR WELD ELECTRODES
- ELECTRODE MECHANISM & ACTUATOR
- BRACE ATTACH CLAMP MECHANISM
- BRACE ATTACH ACTUATOR
- CLAMP ADVANCE ACTUATOR


DETAIL H
SECT F-F
SECT J-J
SECT G-G
SECT A-A
RDM447-2051 SHT°2


A
F
A
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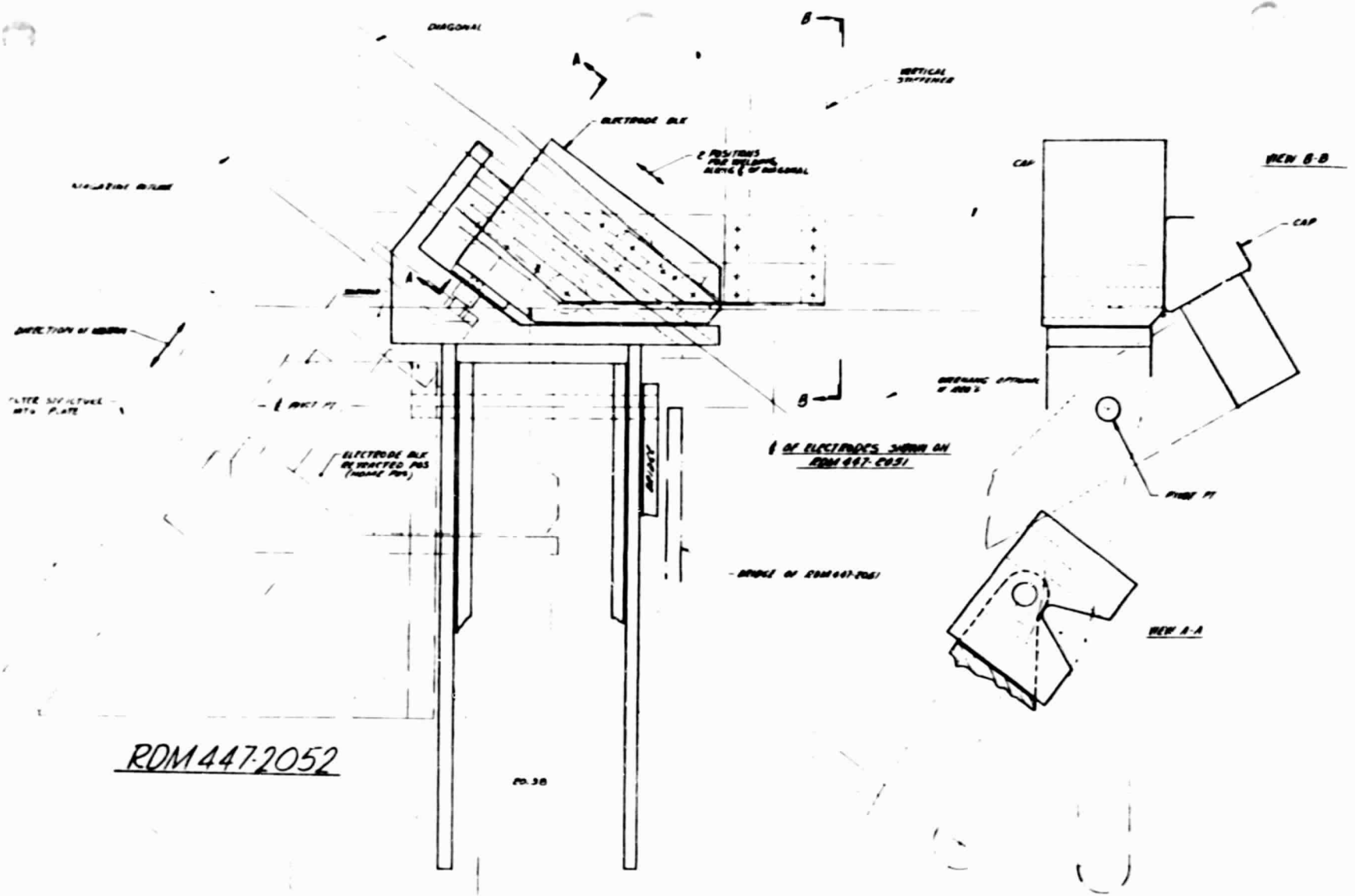
E
XX/D-D
XX/E-E
C
C
RDM447-2051 SHT D
XX/B-B
XX/C-C

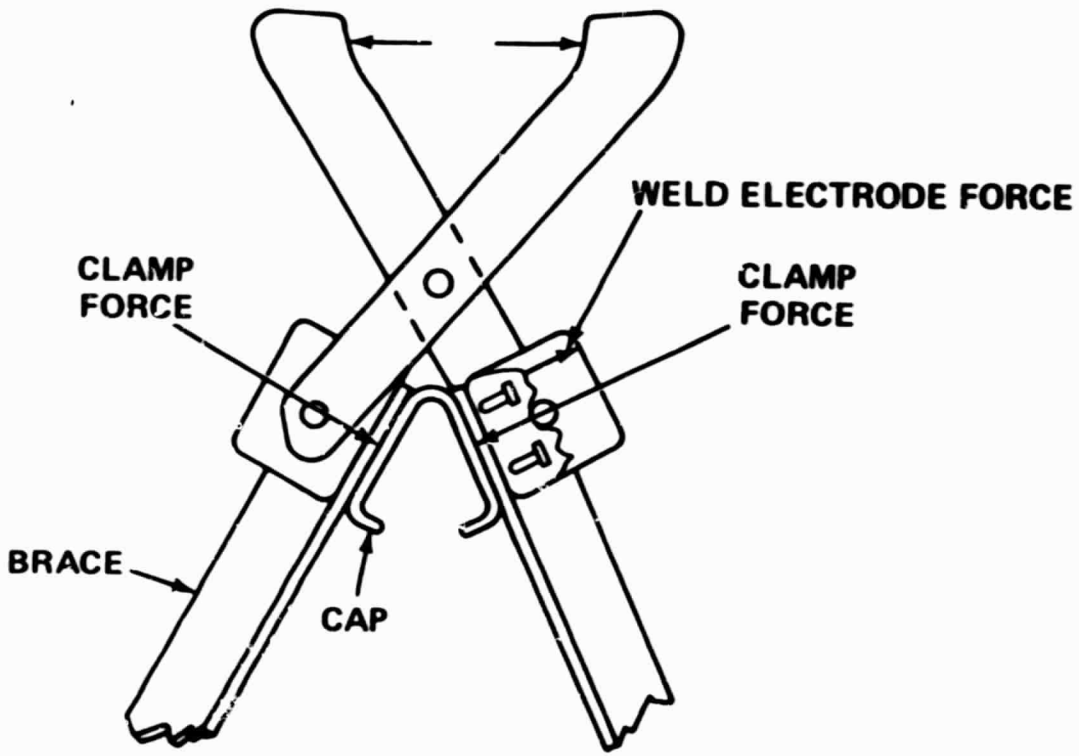


RDM 447-2052

NOTE:
DESIGN SIMILAR TO RDM 447-2037

JOB 102-023-100
STUDY LAYOUT SHOWING ELEC. TOOL BLOCK DEVICE FOR DIAGONAL & STIFFENER INTERSECTION
DWG. RDM 447-2052

CLAMP MECHANISM PRINCIPAL FORCES



SUMMARY – MAGAZINE/DISPENSER SUBSYSTEM

- BRACE DISPENSER MOCKUP FUNCTION TESTED
- BRACE MAGAZINE MODIFIED AS PER PDR
- CLAMP MECHANISM MOCKUP FUNCTION TESTED

UNDETERMINED

- FINAL CONFIGURATION DIAGONAL CLAMP MECHANISM

FACILITY DESIGN

AREAS OF DISCUSSION

- OVERALL CONFIGURATION
- ROLL-FORMING CAP MEMBER
- MAGAZINE/DISPENSER BRACE MEMBERS
- **BRACE ATTACHMENT**
- TRUSS CUTOFF AND INTERNAL SUPPORT
- CONTROLS
- SUMMARY

BRACE ATTACHMENT

PRIMARY SYSTEM

- RESISTANCE SPOT-WELDING

ALTERNATES CONSIDERED

- ULTRASONICS
- HOLLOW INTEGRAL RIVET
- INTEGRAL RIVET
- STAPLING
- ELECTRON-BEAM WELDING
- ADHESIVE BONDING

WELD SYSTEM
PRINCIPAL COMPONENTS

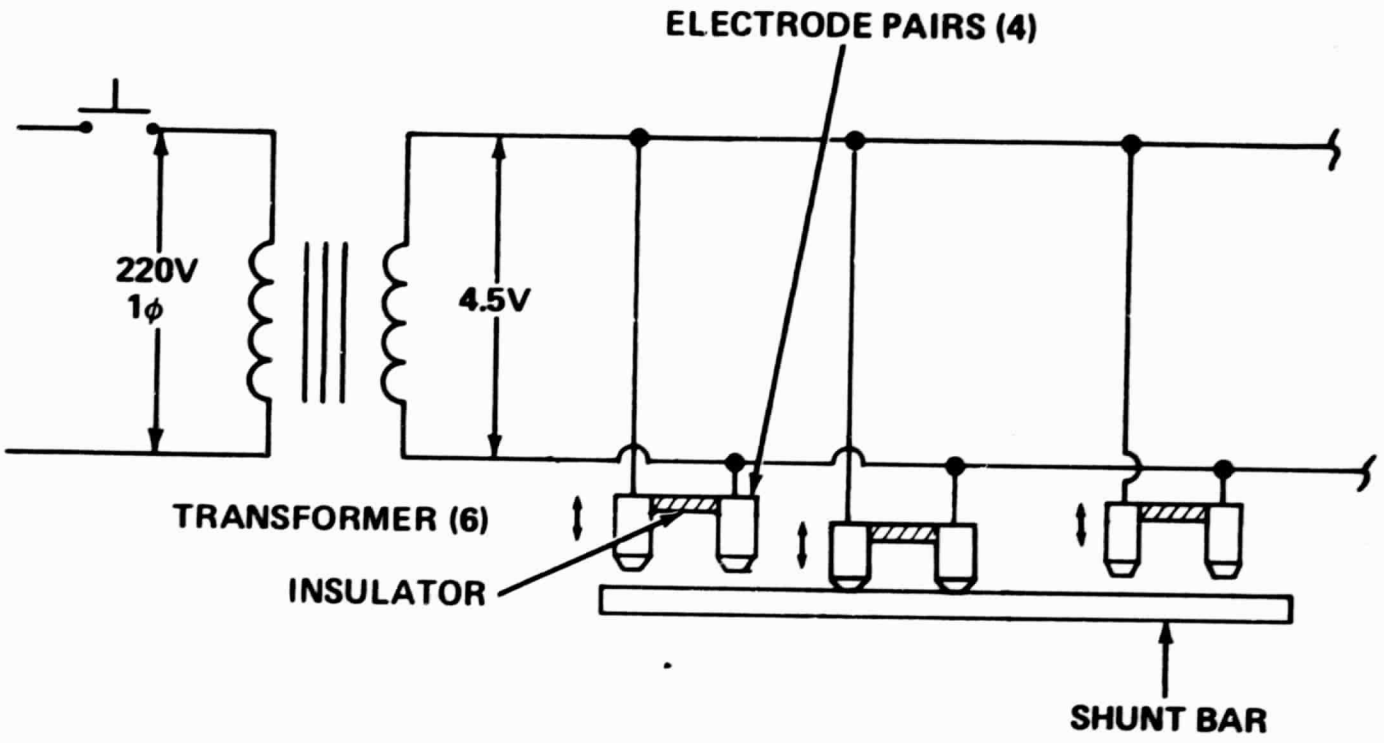
- TRANSFORMER
- CONTROLLER
- POWER CABLES
- ELECTRODES

2105-039W

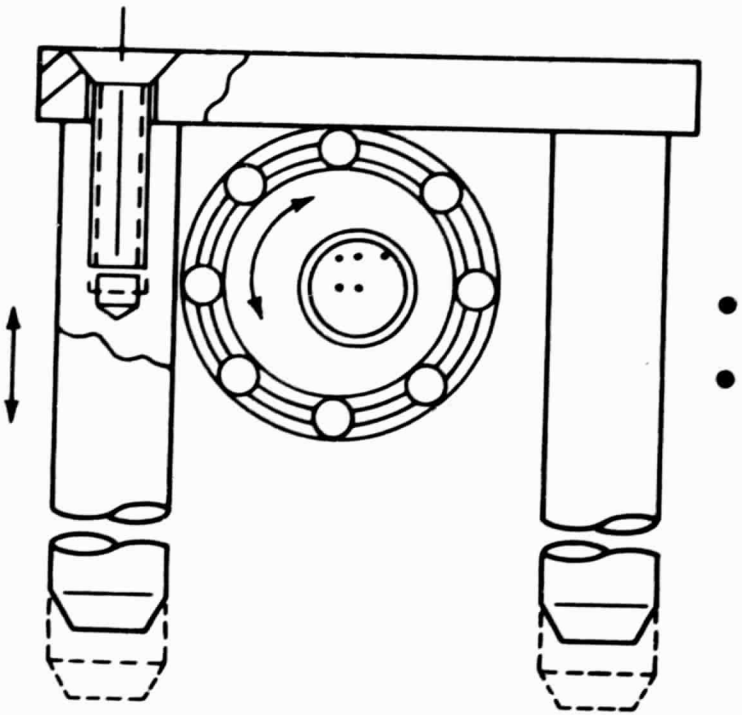
WELD POWER SUPPLY GROUND DEMONSTRATION SYSTEM

- MANUFACTURER – SCIAKY
- QUANTITY – 6
- TYPE – SOLID-STATE A/C
- COOLANT – WATER
- OUTPUT – 63 KV, 4.5 V
- DUTY CYCLE – APPRX. 0.01%
- WEIGHT – 91 KG (200 LBS)
- SIZE – 25.4 x 30.5 x 50.8 CM (10 x 12 x 20 IN.)

WELDING PROCESS SCHEMATIC



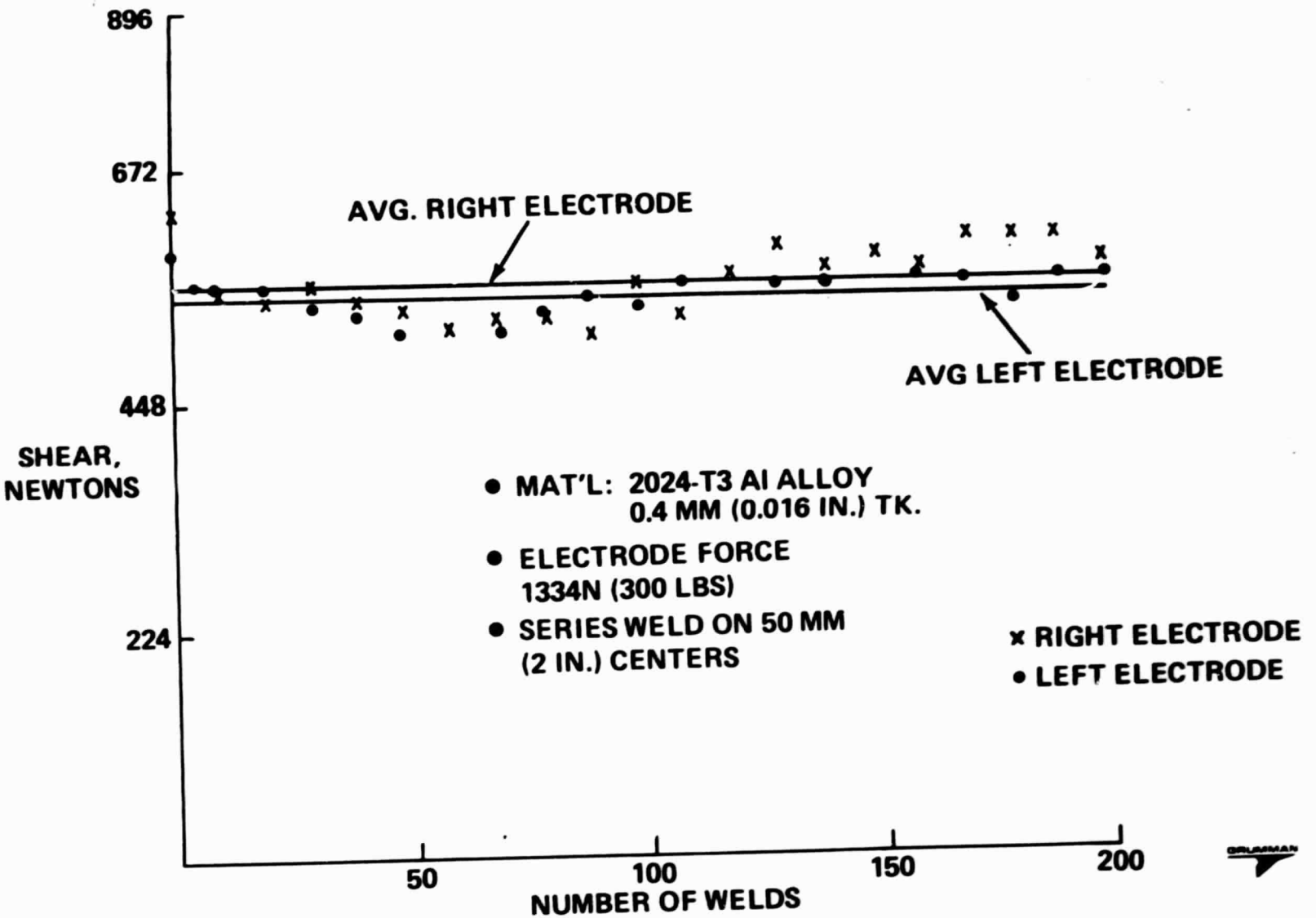
ELECTRODE ACTIVATION MECHANISM



- CAM ACTUATION
- SPRING FORCE ON ELECTRODE

2105-038W

WELD ELECTRODE LIFE TEST



SUMMARY – ATTACHMENT SUBSYSTEM

- SERIES ELECTRODE LIFE-TESTS PERFORMED
- ORDERING SIX TRANSFORMERS AS PER PDR
- WELD QUALITY EXCEEDS LOAD REQUIREMENTS
- ELECTRODE SWITCHING SHOWN IN MOCKUP

FACILITY DESIGN

AREAS OF DISCUSSION

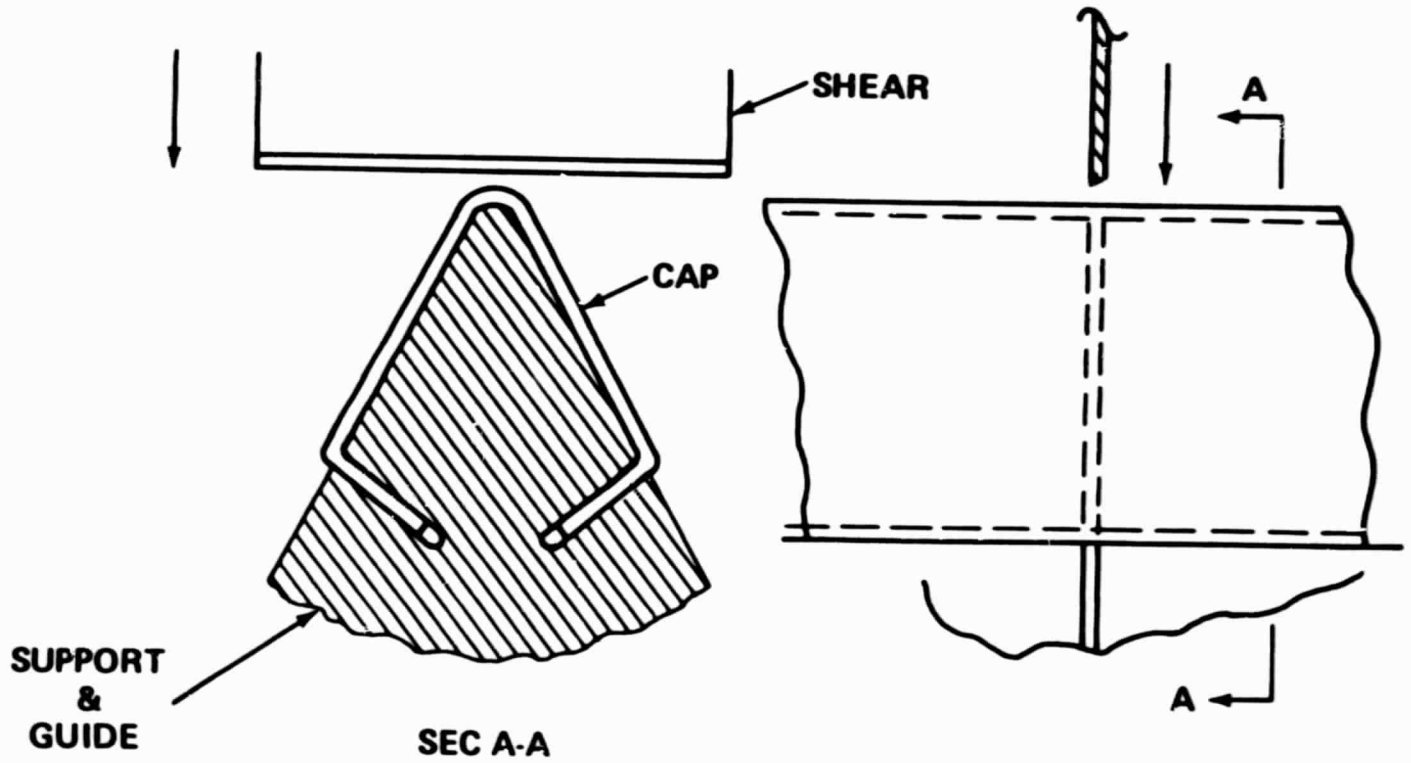
- OVERALL CONFIGURATION
- ROLL-FORMING CAP MEMBER
- MAGAZINE/DISPENSER BRACE MEMBERS
- BRACE ATTACHMENT
- **TRUSS CUTOFF AND INTERNAL SUPPORT**
- CONTROLS
- SUMMARY

TRUSS CUTOFF MECHANISM & SUPPORT STRUCTURE

FUNCTIONS:

- GUIDE TRUSS AFTER ROLL-FORMING
- PROVIDE BACKUP FOR BRACE CLAMP AND WELD
- CUT OFF TRUSS TO PROPER LENGTH

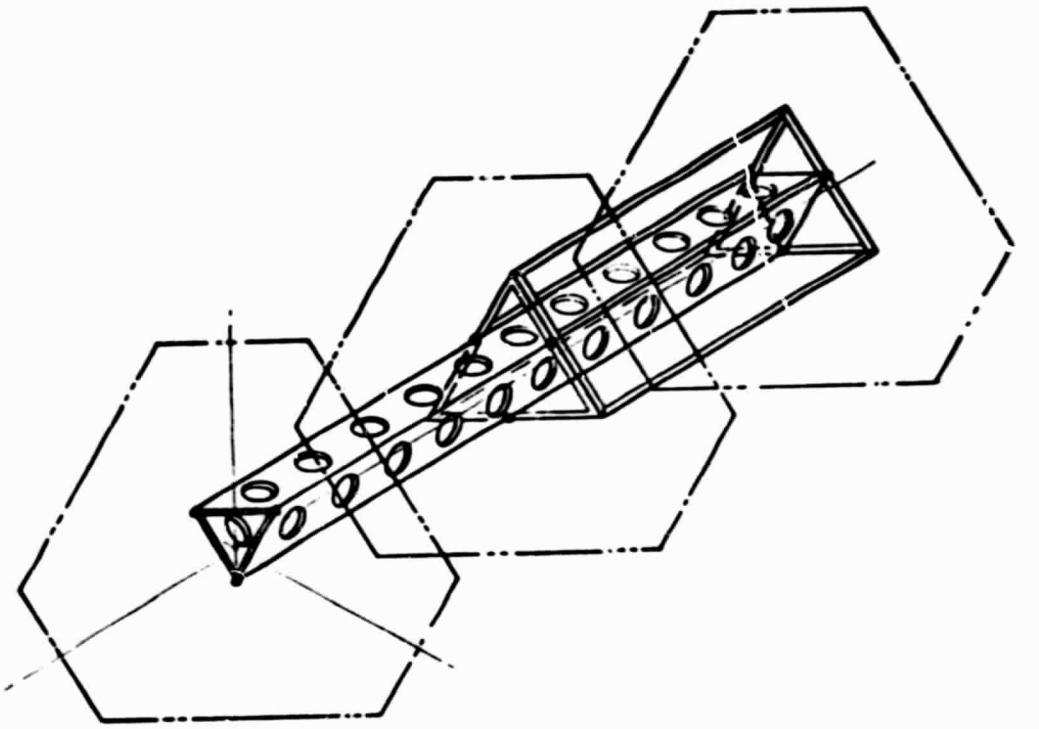
TRUSS CUTOFF MECHANISM



2105-068W

INTERNAL SUPPORT STRUCTURE

- MATERIAL – HOT ROLLED STEEL
- ARC WELD AND BOLTED CONSTRUCTION
- DWG. NO. RDM 447-2069



GRUMMAN

SUMMARY – TRUSS CUTOFF AND INTERNAL SUPPORT SUBSYSTEM

- CUTOFF MOCKUP BEING EVALUATED
- TRUSS SUPPORT CONFIGURATION DEFINED

UNDETERMINED

- FINAL CONFIGURATION TRUSS CUTOF :

GRUMMAN

FACILITY DESIGN

AREAS OF DISCUSSION

- OVERALL CONFIGURATION
- ROLL-FORMING CAP MEMBER
- MAGAZINE/DISPENSER BRACE MEMBERS
- BRACE ATTACHMENT
- TRUSS CUTOFF AND INTERNAL SUPPORT
- **CONTROLS**
- SUMMARY

PERFORMANCE REQUIREMENTS

- BAY LENGTH – 1.5 METERS ± 0.8 MM
- BAY FABRICATION RATE – 60 TO 300 SEC
- MAXIMUM CAP LENGTH VARIATION (40-M BEAM) – 20 MM
- ROLLING MILL DRIVE SPEED – 1.5 TO 3.0 METERS/MIN

DESIGN GUIDELINES

- MAXIMUM USE OF "OFF-THE-SHELF" COMMERCIAL COMPONENTS
- MINIMUM-COST SYSTEM
- INSURE BEAM STRAIGHTNESS
- HIGH RELIABILITY

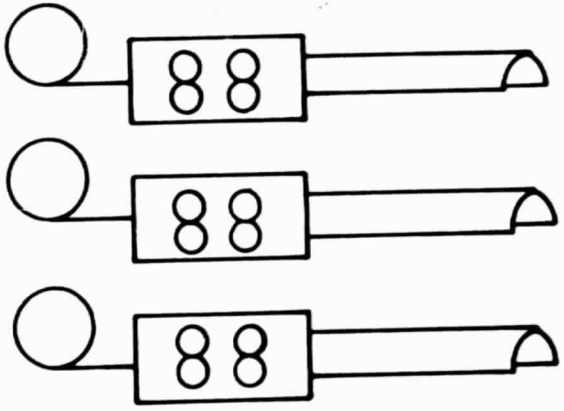
GRUMMAN

PRINCIPAL COMPONENTS

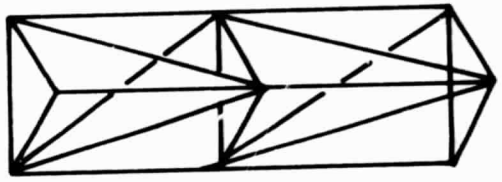
- CENTRAL PROCESSOR
- CAP SYSTEM SERVO
- ASSEMBLY SUBSYSTEM
- OPERATOR CONTROL PANEL
- TELETYPE

CONTROL SYSTEM FUNCTIONS

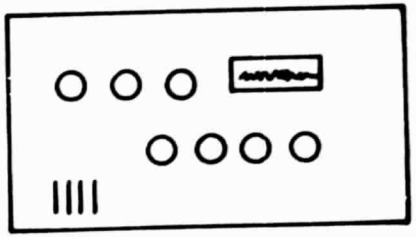
- COORDINATE MOTION OF ROLLING MILLS



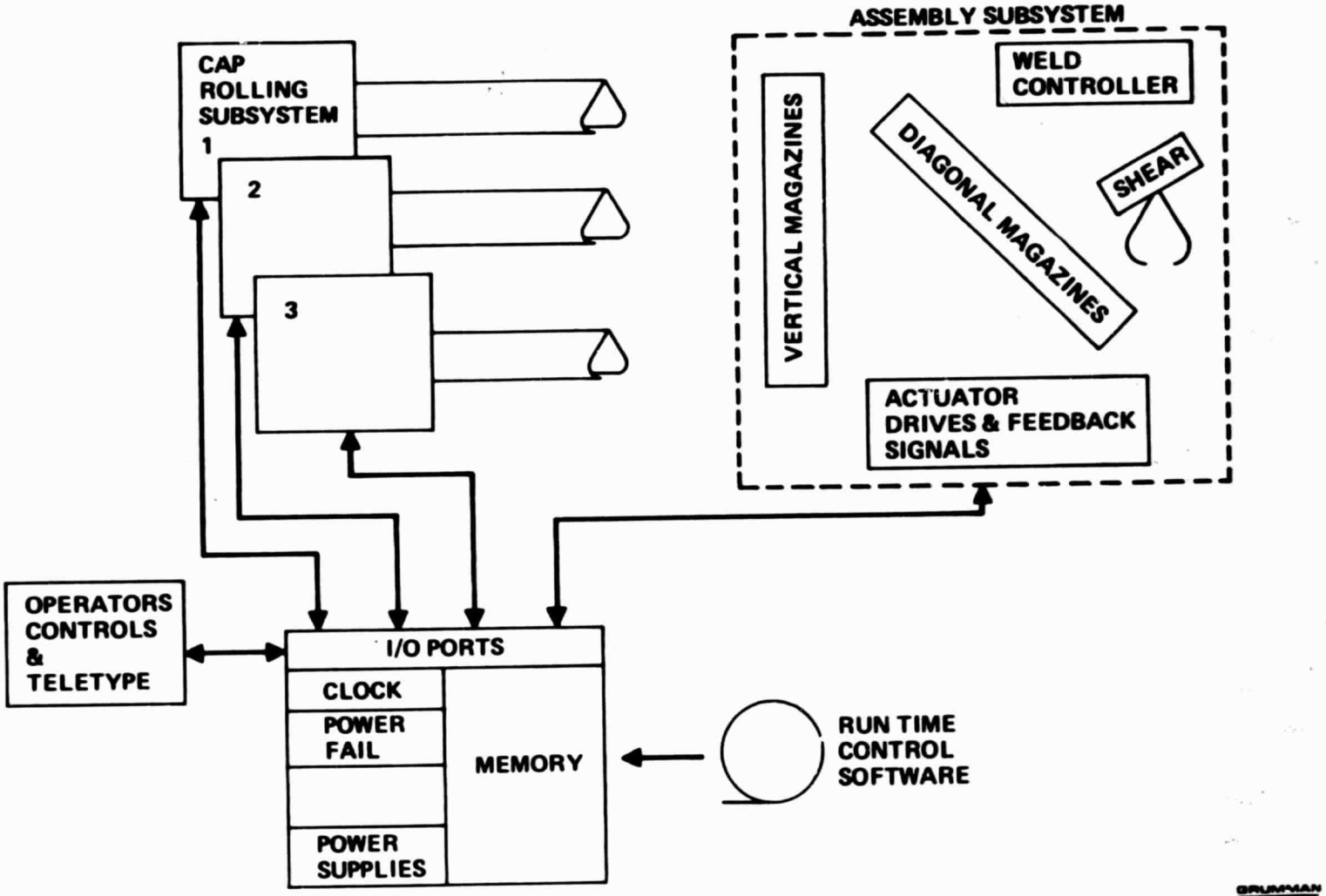
- SEQUENCE EVENTS FOR ASSEMBLY AND FASTENING



- EXECUTE OPERATOR INPUT COMMANDS

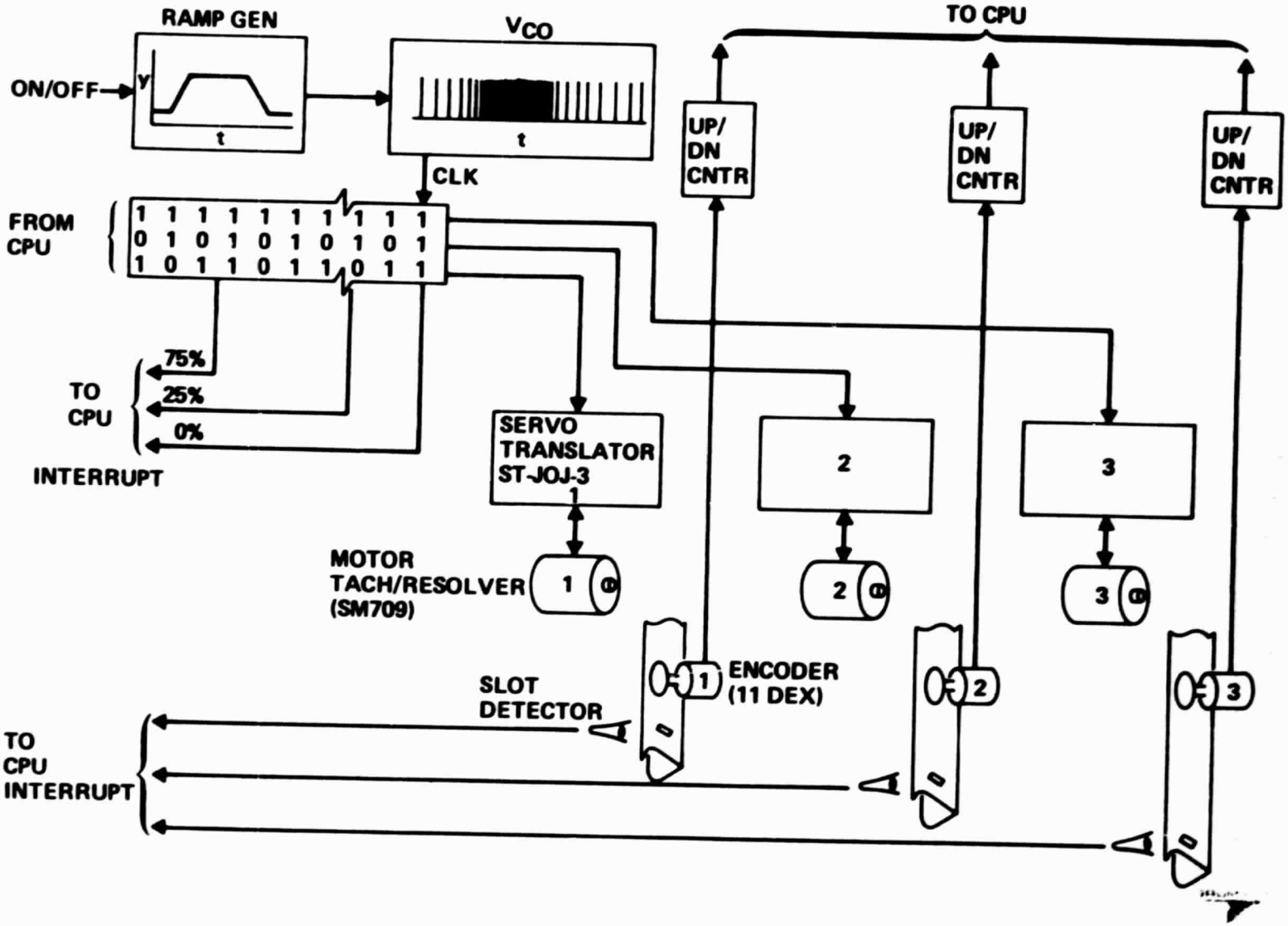


CONTROL SYSTEM OVERVIEW



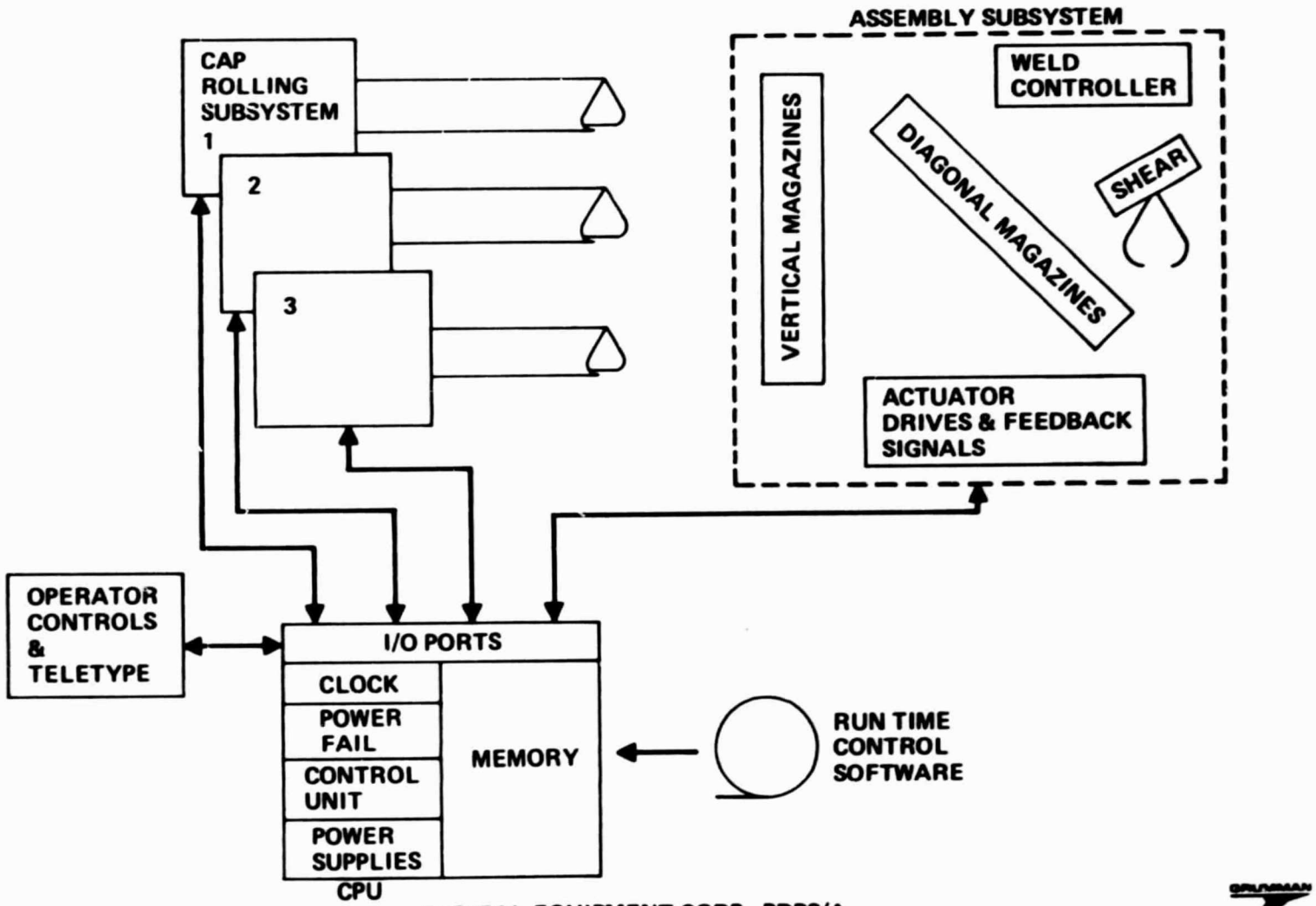
2105-064W

CAP POSITION CONTROLS



2105-062W

CONTROL SYSTEM OVERVIEW



DIGITAL EQUIPMENT CORP - PDP8/A

2105-064W

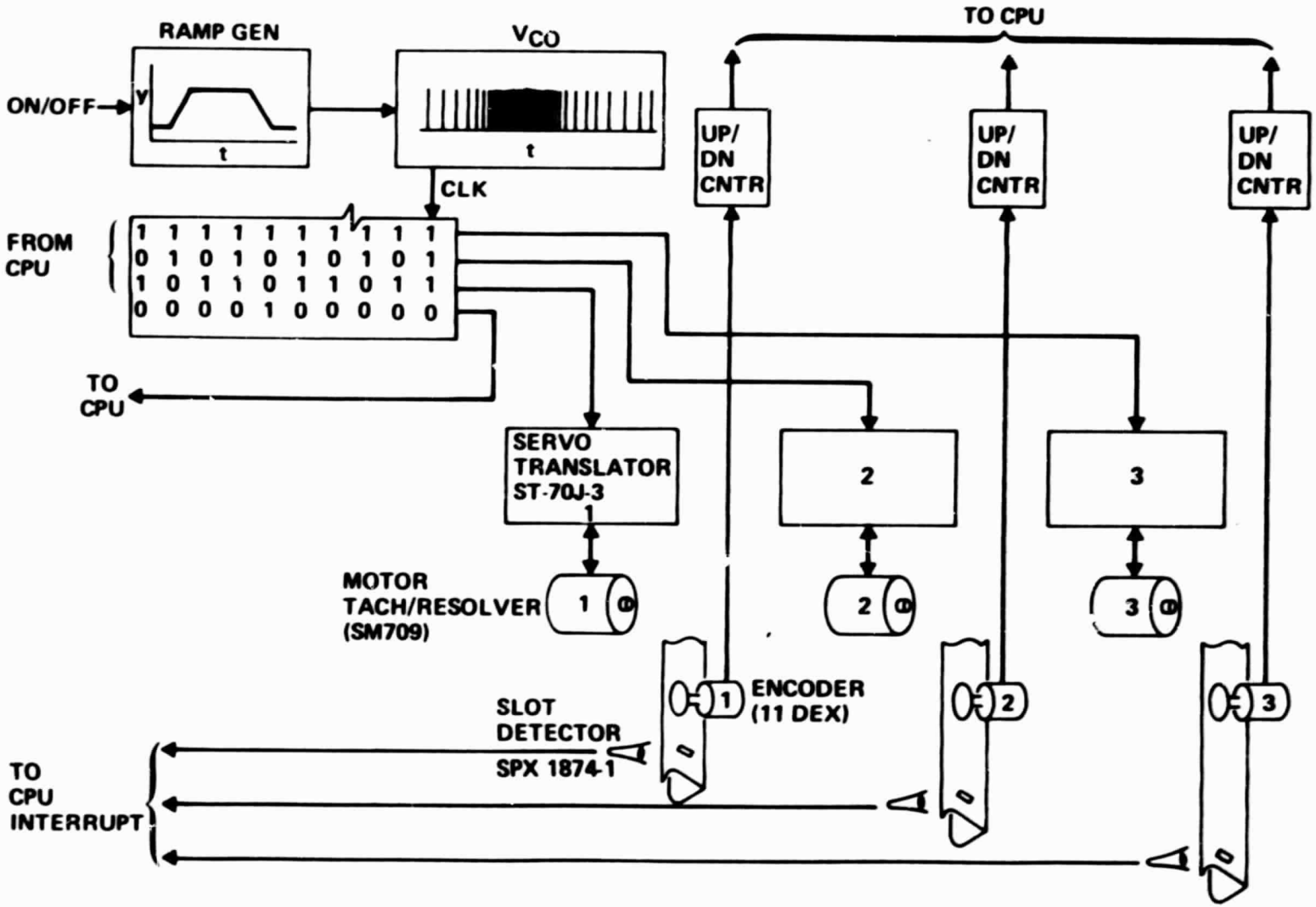
PERFORMANCE SUMMARY

CRITERION	REQUIREMENTS	GOAL
BAY LENGTH (1.5 METERS)	± 0.8 MM	± 0.15 MM
BAY FABRICATION RATE	60 - 300 SEC	100 - 300 SEC
MAXIMUM CAP LENGTH VARIATION (40-METER BEAM)	± 20 MM	± 0.15 MM
ROLLING MILL DRIVE SPEED	1.5 - 3.0 M/MIN	1.5 - 3.3 M/MIN

SELECTION OF CENTRAL PROCESSOR (PDP8/A)

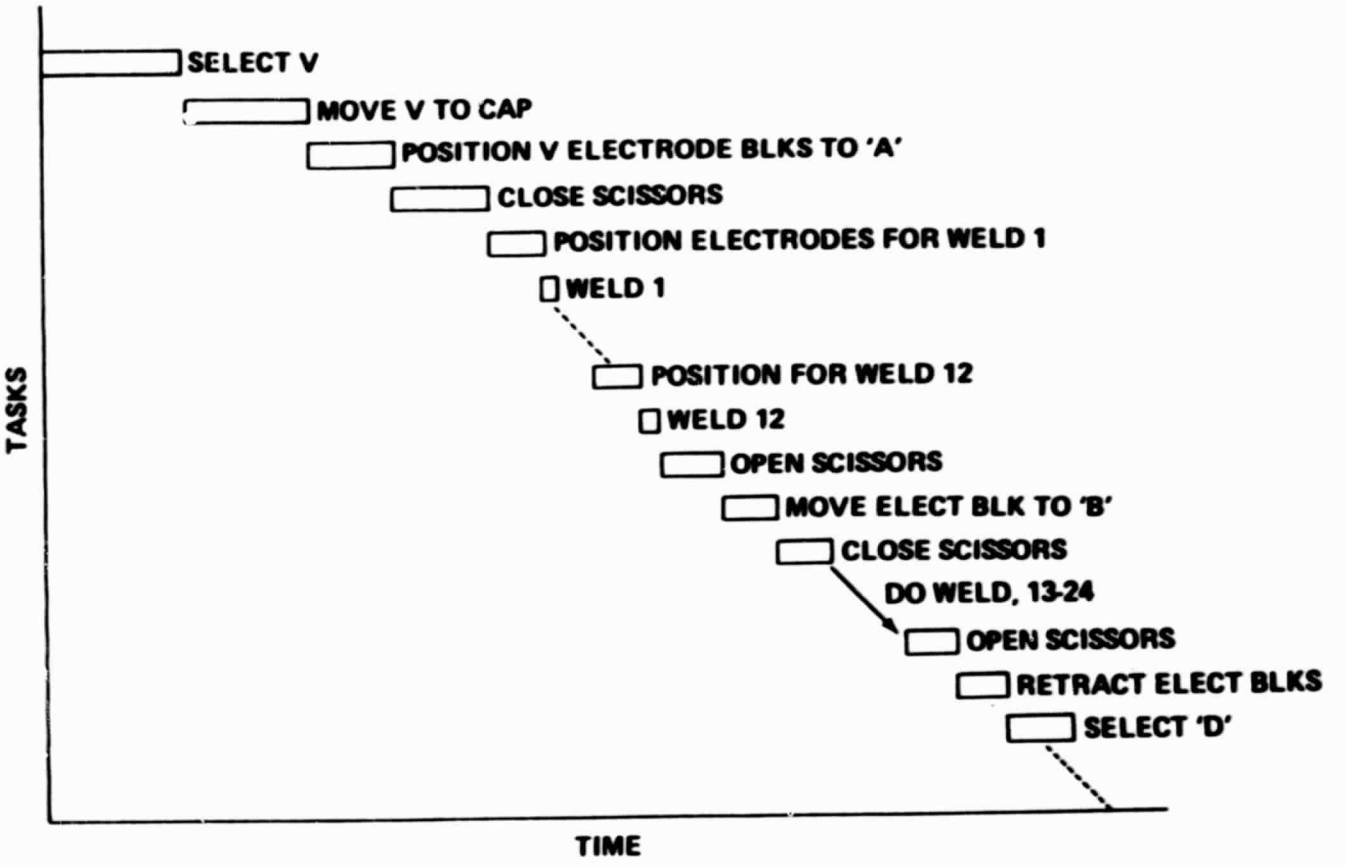
- COMMERCIALLY AVAILABLE
- KNOWN HIGH RELIABILITY
- LOW COST
- ROOM FOR EXPANSION
- EXTENSIVE SOFTWARE SUPPORT
- EASE OF INTERFACING

CAP POSITION CONTROLS

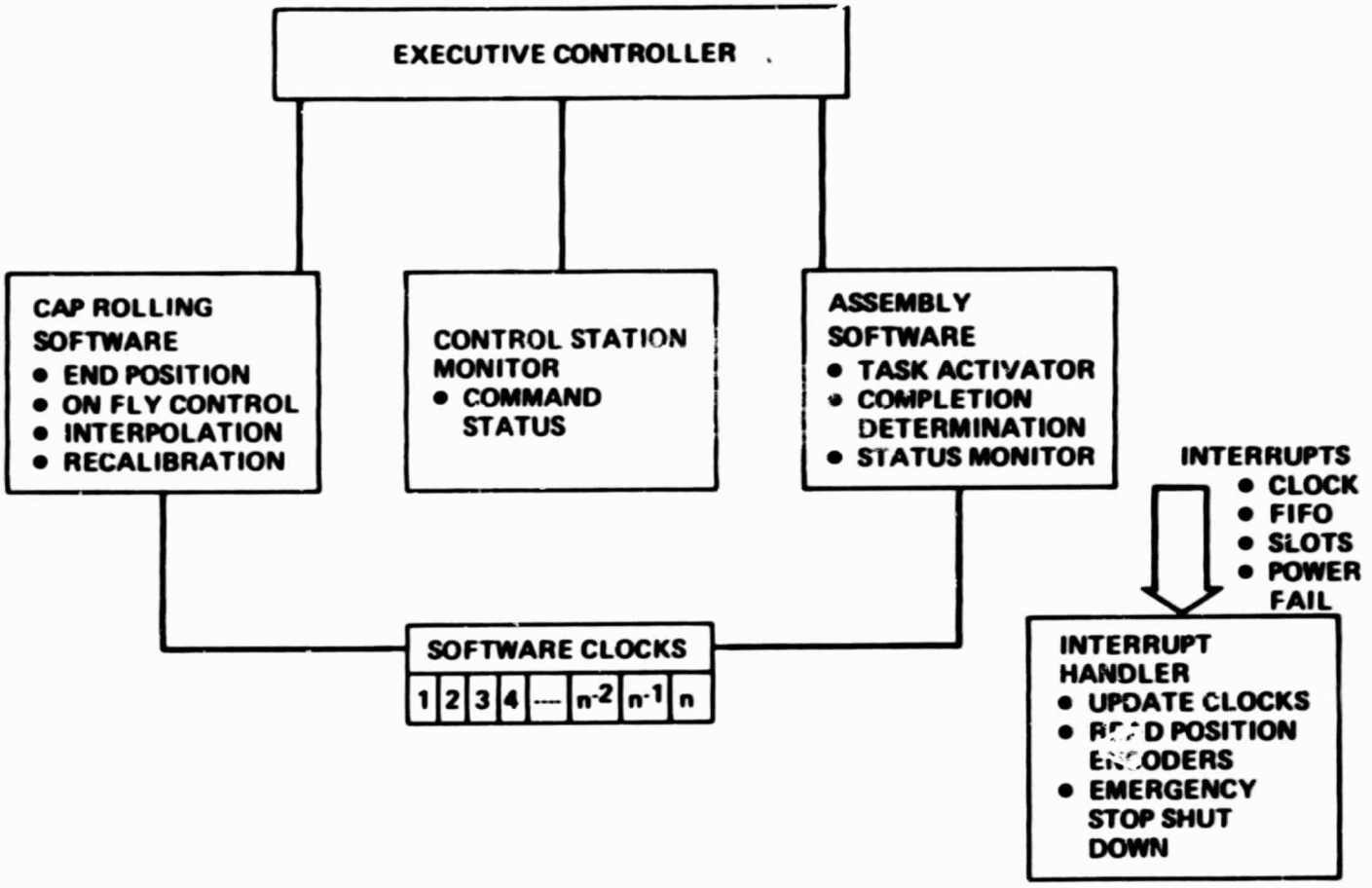


2185-062W

ASSEMBLY SUBSYSTEM SEQUENCE



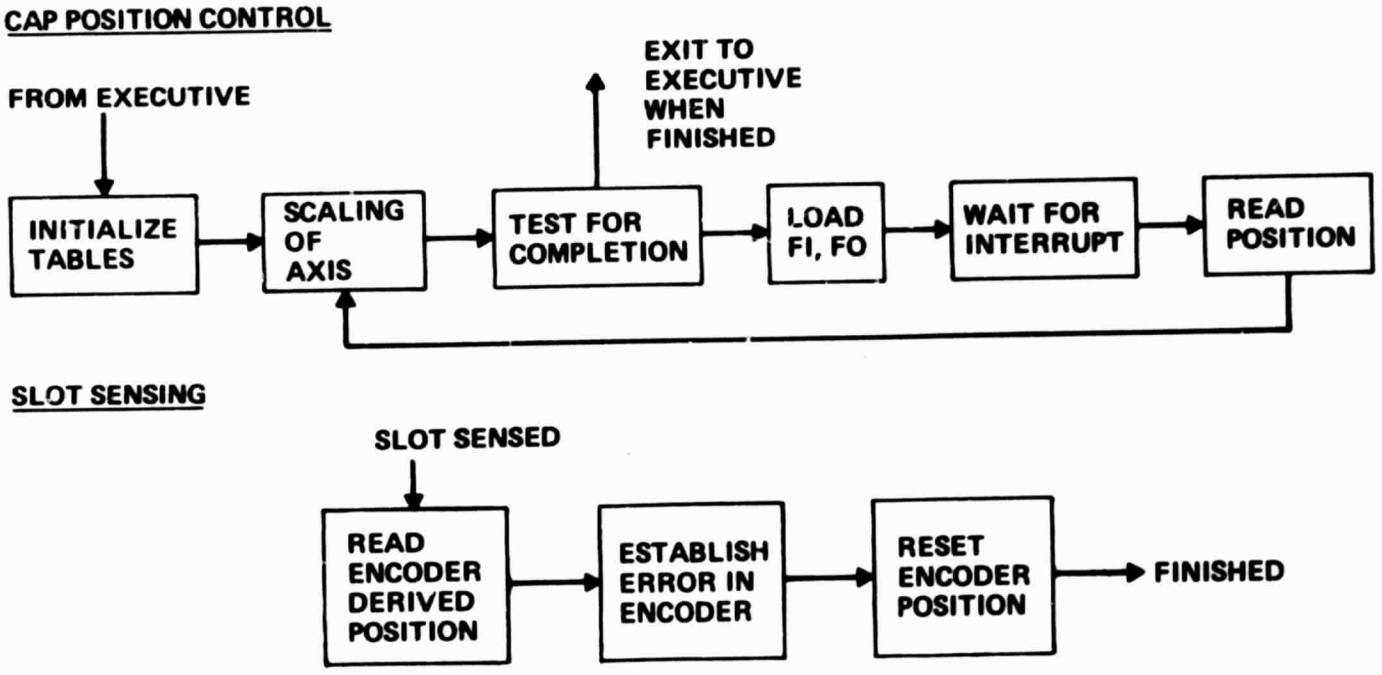
SOFTWARE HIERARCHY



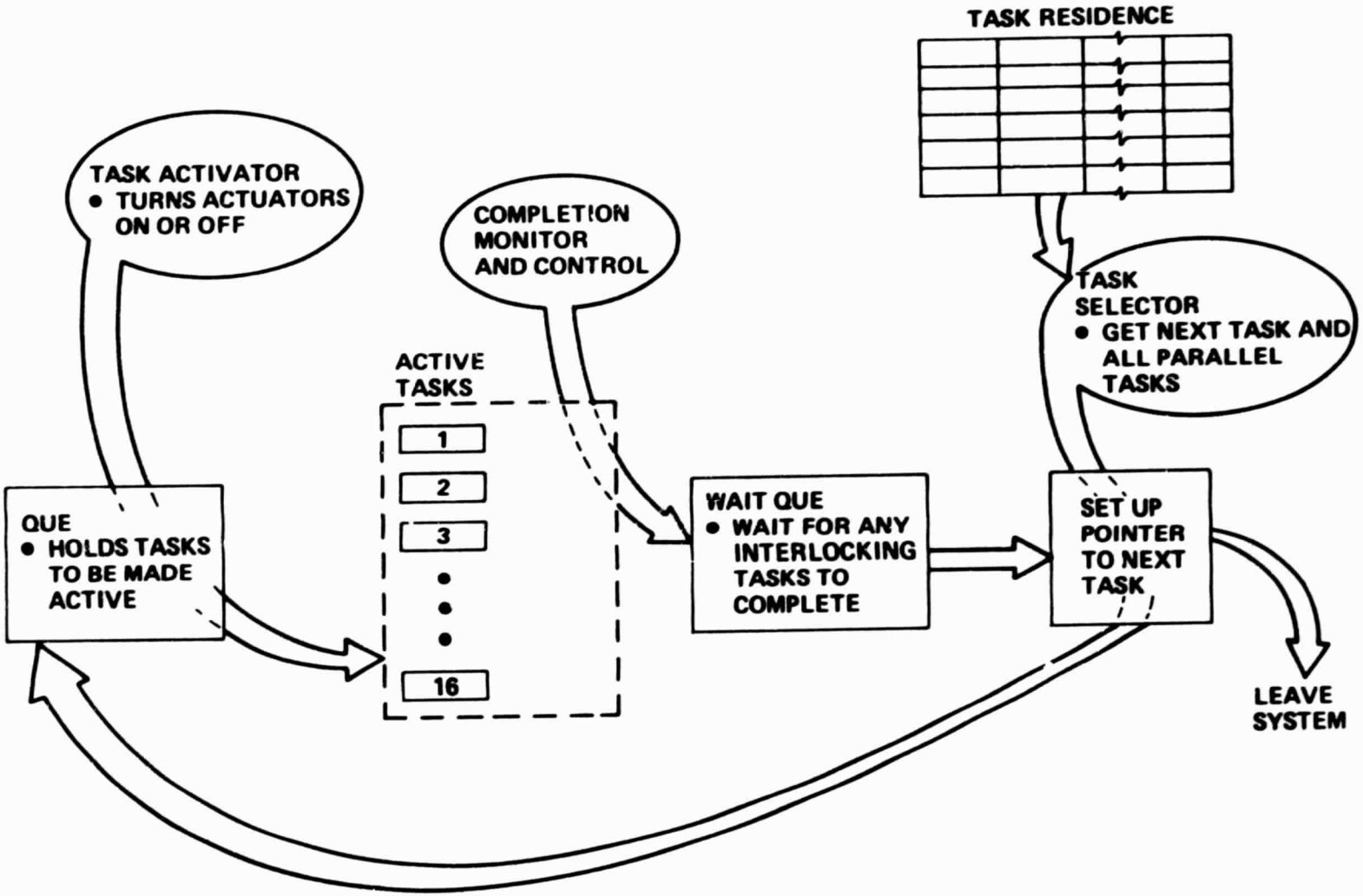
GRUMMAN

2105-065W

SOFTWARE


CAP POSITION CONTROL
FROM EXECUTIVE
EXIT TO EXECUTIVE WHEN FINISHED
INITIALIZE TABLES
SCALING OF AXIS
TEST FOR COMPLETION
LOAD FI, FO
WAIT FOR INTERRUPT
READ POSITION
SLOT SENSING
SLOT SENSED
READ ENCODER DERIVED POSITION
ESTABLISH ERROR IN ENCODER
RESET ENCODER POSITION
FINISHED

ASSEMBLY SUBSYSTEM SOFTWARE



2105-067W

SUMMARY

- OVERALL ARCHITECTURE OF CONTROL SYSTEM DEFINED
- MAJOR CONTROL ELEMENTS SELECTED
- EQUIPMENT ORDERED:
  - COMPUTER SYSTEM
  - ROLLING MILL DRIVES
- SOFTWARE DEFINED
- PROCEEDING WITH DETAIL DESIGN, SOFTWARE GENERATION AND COMPONENT PROCUREMENT
- UNDEFINED:
  - CONTROL CIRCUITRY FOR ACTUATORS
  - CABLING AND PACKAGING DETAILS

2105-157W

FACILITY DESIGN

AREAS OF DISCUSSION

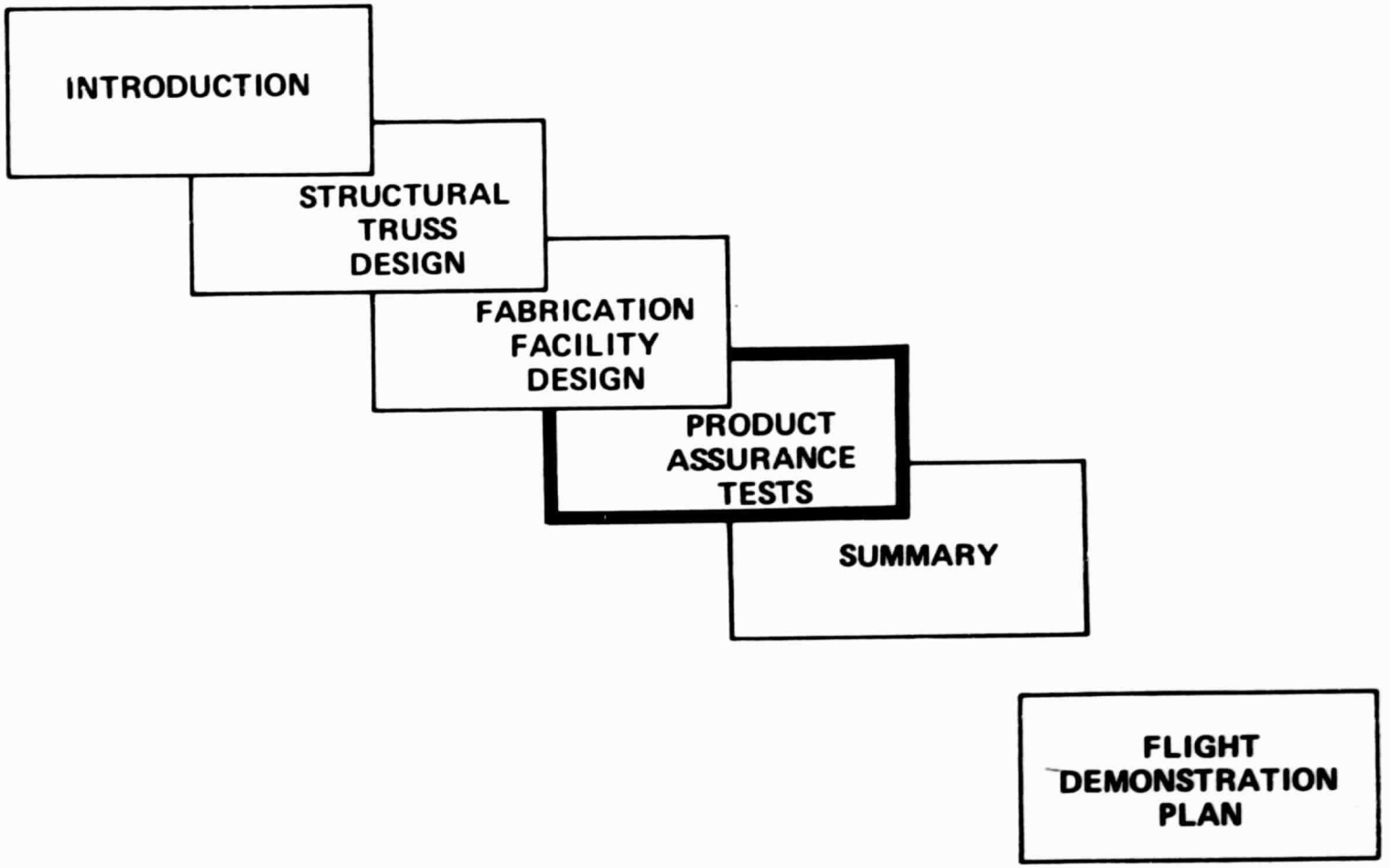
- OVERALL CONFIGURATION
- ROLL-FORMING CAP MEMBER
- MAGAZINE/DISPENSER BRACE MEMBERS
- BRACE ATTACHMENT
- TRUSS CUTOFF AND INTERNAL SUPPORT
- CONTROLS
- SUMMARY

SUMMARY-FACILITY DESIGN

	OVERALL CONFIGURATION	ROLL FORMING	BRACE DISPENSER	ATTACHMENT	TRUSS CUTOFF	CONTROLS	
WORKING MOCKUP	✓	–	✓	✓	✓	–	
PRELIMINARY TESTING PERFORMED	NA	✓	✓	✓	✓	✓	
PROVEN COMMERCIAL PROCESS EQUIPMENT	–	✓	–	✓	–	✓	
COMMERCIAL EXPERTISE UTILIZED	–	✓	–	✓	✓	✓	
PDR CONCURRENCE	–	✓	✓	✓	–	✓	
COMPATIBLE WITH SHUTTLE GEOMETRY	✓	✓	✓	✓	✓	✓	
COMPATIBLE WITH SHUTTLE POWER REQ'MT	–	✓	✓	✓	✓	✓	

FACILITY DESIGN PLAN

- OBTAIN CONCURRENCE WITH MSFC ON DESIGN FOR ALL SUBSYSTEMS
- START FABRICATION AND PROCUREMENT OF DETAIL PARTS
- CONTINUE WITH CONSTRUCTION TO MEET EXISTING PROGRAM SCHEDULE REQUIREMENTS


INTRODUCTION
STRUCTURAL TRUSS DESIGN
FABRICATION FACILITY DESIGN
PRODUCT ASSURANCE TESTS
SUMMARY
FLIGHT DEMONSTRATION PLAN

SFDS QUALITY ASSURANCE

OBJECTIVE: DELIVERY OF A FACILITY FUNCTIONING AT REQUIRED OPERATING CONDITIONS AND RATES THAT REPEATEDLY PRODUCES BEAMS TO ENGINEERING DRAWING REQUIREMENTS

MAJOR QUALITY ASSURANCE TASKS

- FABRICATION OF FACILITY
- EVALUATION OF FABRICATED BEAMS

FACILITY FABRICATION

- DRAWING REVIEW
- VENDOR MATERIALS AND COMPONENTS
- FABRICATION AND ASSEMBLY
- FUNCTIONAL TESTS

BEAM EVALUATION

- CONVENTIONAL INSPECTION AND N.D.T. DURING GROUND PHASE
- INVESTIGATE ADVANCED AUTOMATED SYSTEMS FOR FLIGHT APPLICATION
- PRIMARY INSPECTION AREAS
  - ROLL FORMED CAP MEMBERS
  - SPOT WELD ATTACHMENTS
  - BRACE POSITIONING
  - ASSEMBLY ALIGNMENT

ROLL FORMED CAP MEMBERS

- BENDING RADIUS INTEGRITY
  - FLUORESCENT PENETRANT
  - MANUAL EDDY CURRENT
- GEOMETRY AND STRAIGHTNESS
  - VISUAL AND DIMENSIONAL

2105-114

BRACE POSITIONING

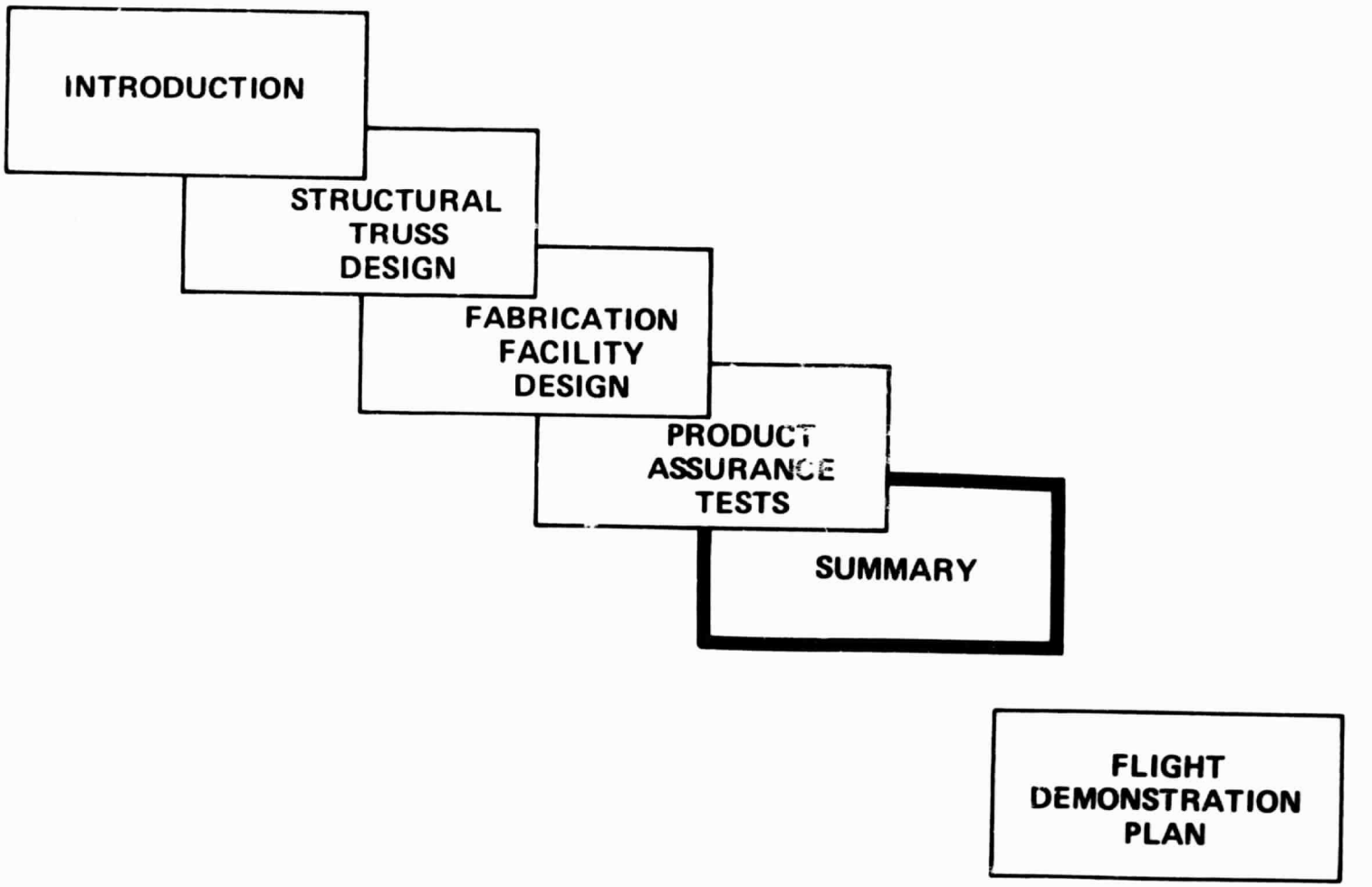
- EVALUATE TEST BEAMS TO VERIFY
  - BRACE LOCATION ON CAP MEMBER
  - BRACE ALIGNMENT
  - SPOT WELD LOCATION
- UTILIZE CONVENTIONAL DIMENSIONAL INSPECTION

SPOT WELD ATTACHMENTS

- FABRICATE TEST SAMPLES TO VERIFY WELDING PARAMETERS
- PREPARE PROCESS CONTROL TEST SPECIMENS BEFORE AND AFTER BEAM FABRICATION
- VISUAL AND RADIOGRAPHIC EVALUATION OF ATTACHMENTS AT INTERVALS ALONG TEST BEAMS

ASSEMBLY ALIGNMENT

- OPTICAL TECHNIQUE TO MEASURE BOW AND TORSIONAL DISPLACEMENT
- IN PROCESS EVALUATION DURING DE-BUGGING PHASE
- OVERALL MEASUREMENT OF TEST BEAMS
- EVALUATE ADVANCED TECHNIQUES FOR FLIGHT MONITORING


INTRODUCTION
STRUCTURAL TRUSS DESIGN
FABRICATION FACILITY DESIGN
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2105-008W

SUMMARY

- STRUCTURAL TRUSS DESIGN
- FABRICATION FACILITY DESIGN
- PRODUCT ASSURANCE TESTS
- NEXT PROJECT MILESTONE
- QUARTERLY REVIEW ACTION ITEMS